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THE

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[FOURTH SERIES.]

ART. XL.—*Polar Climate in Time the Major Factor in the Evolution of Plants and Animals;* by G. R. WIELAND.

THE long period of physical evolution which preceded and made possible the appearance of life on the globe forms a subject with which the physicist, the chemist, and the astronomer must deal in common. For the history of these changes is an inferential one based on the physical properties, constitution, and relative position of the materials of the globe in space. And indeed the same is largely true of the immense period of time which doubtless elapsed from the appearance of whatever was the most primitive form of protoplasm to the evolution of the oldest organisms now found fossilized. From this crucial period onward, the paleontologist can decipher the main facts in the story of life on the globe, although he can at no point dispense with the mathematical sciences. Especially is this true when it is attempted to gain a knowledge of climate in time, certainly the most tangible and readily understood, and doubtless the fundamental factor in evolution. To make this latter statement clear let the extent to which organic growth and life-processes involve chemism, be recalled in the light of the more recent experiments of such investigators as Loeb and Matthews. Now chemism refers solely to those properties of matter which are unchangeable and eternal. On the other hand, chemical change is governed by the conditions of electrification, and of heat, light, and moisture, which are none other than the elements of climate, or weather conditions. Life then, as far as we have succeeded in scrutinizing it, is a function of variable mechanical factors combined with chemism, which is fixed, and of climate as dependent mainly on the

manner of terrestrial reception of the solar radiant energy. Climate, although following a fairly fixed trend, in itself subject in so far as the globe is concerned to an evolutionary course, is at all times in given localities subject to the accidence of countless movable conditions.

Thus it is that in any attempt to reach a general idea of the course of life on the globe, the scene of its origin, the location of dispersion centers, and the more active factors in the changing of organisms and evolving of new species, it at once becomes necessary to consult first of all the astronomical and physical records. Secondly, it becomes a subject of the highest interest when we are able to consult both the physical and biologic record in those later periods of the earth's history where these overlap. Each then supplements the other. In taking a glance, however, at the subject of climate in time, and particularly polar climate, I shall, leaving the consideration of the pre-fossil period to the geo-physicist, mention but briefly several associated theories of an astronomical or physical nature, and then confine myself mainly to biologic data. And I hold that the evidence taken in its entirety indicates as most probable the polar origin of life, and the development throughout more especially later geological time of the great groups of animals and plants markedly possessing invasive power, mainly in boreal regions. Secondarily these northern forms dispersed themselves southward over the V-shaped continents, and there appears to be but little likelihood that austral forms ever played as conspicuous a part in the great faunal and floral movements of the past. In a word, that the great evolutionary *Schauplatz* was boreal is possible from the astronomical relations, probable from the physical facts, and rendered an established certainty by the unheralded synchronous appearance of the main groups of animals and plants on both sides of the great oceans throughout post-Paleozoic time. Moreover, the efficient cause of this origin in high latitudes of hardy and effective colonizers is to be sought for in the vicissitudes of polar climate as compared with the more equable and static conditions of the tropics.

Climate in time, or geological climate, may be considered as the resultant of two sets of factors, both of which are subject to an evolutionary process which is in the one set more or less irregular and subject to cataclysm, and in the other more purely differential or secular. The first set includes chiefly altitude, emergence and stability of the land masses, deflection of the winds and tides, and probably reception of meteoric material. The main possible differential factors of geological climate are: Change in obliquity of the ecliptic, axial fixity, internal heat reaching the surface, rate of solar radiation, length of day,

composition of the atmosphere, seasonal distribution of light, and orbital eccentricity.

Now a point of prime importance when we come to the consideration of such topics in connection with the fossil record is the vivid impression we get of the general stability of the globe, and of the main features of climate throughout very long periods of time. The facts of the fossil record lend much of reality to our ideas of the relative or the actual permanence of matter. But it would only be presumption on the part of one who has interested himself almost entirely with biological studies to attempt an arbitrament of the results of research on fundamental physical and astronomical subjects. It will, however, doubtless suffice for the purposes of the present argument if but two of the above climatic factors subject to secular change,—namely, *axial fixity*, and *orbital eccentricity*, be here mentioned at any length.

Axial Fixity.—Variations of latitude due to motion of the poles are theoretically due to mountain making, denudation, and glacial ice caps, and though slight, have with increasing refinement of astronomical measurement become determinable. As the result of prolonged calculation Dr. S. C. Chandler of Cambridge finds evidence of polar shifting in all reliable observations since 1750. From the available data he finds the motion of the pole to be a much varying component arising from an annual revolution in a narrow ellipse about 30 feet long, but varying in form and position, and a revolution in a circle about 26 feet in diameter with a period of about 428 days.

According to Croll, the shifting of the southern ice caps to the north would move the earth's center of gravity from 500 to 1000 feet, but this would in part be compensated by oceanic shifting. It is evident that the change from this cause must be slight. And Lord Kelvin holds that the equatorial bulge is such that no geologic changes of surface could have possibly altered the position of rotation sufficiently to sensibly affect climate.

Nor is it likely that accumulations of extra-terrestrial material in some one quarter of the globe could ever have had such an effect. If so, there should be some stratigraphical evidence of occasional local large aerolitic deposits. But none are known and the facts indicate that in the long run the surface of the globe has as a whole received accretions from without about equally. Beyond the slight movements above given there is, therefore, no evidence of departure from a relatively fixed position of the earth's axis, and until direct evidence has been adduced, it is both legitimate and necessary to set aside as valueless all mere speculations to the contrary.

Orbital Eccentricity.—At times of high eccentricity of the earth's orbit, secondary climatic changes are set up which have been the subject of profound discussion ever since the publication of James Croll's "Climate and Time," in which he contends strenuously that periods of high eccentricity are causes of climatic change sufficiently great to produce a glacial epoch in the hemisphere passing through aphelion winter.

Let us recall that according to Croll's theory the causes of glacial periods are physical, not astronomical. That is to say, solar radiation remaining approximately constant, orbital eccentricity does not in itself produce any diminution in the sum total of solar heat received each year by the entire surface of the globe, or at any latitude. This follows from three causes; 1st, by Kepler's second law the radius vector sweeps over equal areas in equal periods of time; 2d, the amount of heat received is inversely as the square of the distance from the sun; and 3d, the orbit of the earth is constant in the long run as regards its *major axis* and the length of the year, the increase of heat with eccentricity being, according to Sir John F. Herschel, less than ·005 of the total solar heat received now, an amount too slight to markedly influence climate.

When eccentricity is high, therefore, summer is shorter and hotter and winter longer and colder, or *vice versa*, depending on the change in perihelion and aphelion due to the precession of the equinoxes, but the actual yearly amount of solar heat received will be fairly constant for any given latitude.

The argument of Croll is that the true causes of glaciation following eccentricital variations result from the entailed disturbances in the ocean currents, the winds, the rain and snowfall, atmospheric humidity, and (first suggested by Newcomb) increased radiation of heat into space, as temperature rises during the short perihelion summer.*

In addition, A. R. Wallace† has pointed out that these climatic factors have been profoundly affected in the polar regions by changes in the land masses resulting in much modification in the warm and cold currents, and, especially, altitude and the winter storage of cold, which is not offset by any similar storage of summer heat. Now to go into this question at great length, nor can it be fully discussed short of this, is hardly within the scope of the present thesis. And to announce a mere opinion is of course not argument. But it does seem to me that the contention of Croll (pp. 57-66 of "Climate and Time") that the low temperatures of the Antarctic regions are due in considerable measure to the cumulative cooling effect of

* On Some Points in Climatology. A Rejoinder to Mr. Croll. This Journal, vol. xxviii, No. 157, 1884.

† Island Life.

great bodies of ice and snow there found, and that such effects would be heightened if the orbital eccentricity were now much higher, is fairly sustained. It is doubtless true that the great mountainous area of Antarctica is mainly responsible for a condition which is in a lesser degree paralleled by the Greenland ice cap,* and that a much heavier Arctic ice cap would be present were it not for the deep polar sea discovered by Nansen.

But there are no known facts invalidating such impressive testimony as that afforded by the conditions at Sandwich Land, as so graphically described by Capt. Cook. He says, "We thought it very extraordinary that an island between 54° and 55° south latitude should in the very height of summer be almost covered with frozen snow several fathoms deep, . . . masses of ice were continually breaking off and dropping into the sea with a sound like a cannon . . . . . the savage rocks raised their lofty summits till lost in the clouds and the valleys were covered with seemingly perpetual snow." On the other hand, depending on the course and source of the prevailing winds and currents, low-lying lands with fairly equable summers are often found in close proximity to glacier covered regions. Indeed snow and ice seldom accumulate in Arctic lowlands. According to Lieutenant Payer, during the short summer in high latitudes under the influence of dry winds and the sun the ice fields diminished four feet in thickness, or the equivalent of 45 inches of rain. And most northern travelers have noted the sudden burst of luxuriant herbaceous vegetation on the Tundras as soon as the cold winds cease to blow in from the snow fields and ice packs, and thus blanket the winter store of cold with a fog, sleet, and snow-laden atmosphere. Moreover, F. W. Harmer has shown, in one of the most important contributions to the subject of climatology made in recent years,† that many of the phenomena of the "Great Ice Age" may be accounted for in a simple manner on the basis of alterations in the course of the Gulf Stream, in the prevailing winds, and in the shifting of the areas of prevailing high and low barometer, with respect to the land masses surrounding the polar area. It is not, however, the purpose to pass any final judgment, or formulate a theory as to glacial epochs.

* From what was previously known of temperatures and of ice and snow conditions, Nansen had supposed that his great difficulty in crossing the Greenland ice cap would be due to melting snow during the long summer day. But to his great surprise he found mid-winter conditions on the ice cap, and he and his men suffered from well-nigh uncontrollable thirst during their entire journey over it, in the month of August being dependant for drinking water on small quantities of snow melted against their bodies.

† The influence of winds on climate during the Pleistocene epoch; a Palæometeorological explanation of some geological problems.—Quar. Jour. of Geol. Soc., August, 1901.

From the great mass of facts, only the few just given are selected, because they rivet attention to the true nature of Arctic climates as we find them now, and help us to better call to mind the extent of the changes which the geological and paleontological record, and this is the main point, shows them to have undergone. Let us note further, that the several Greenland, New Siberian Island, and Spitzbergen plant beds show that secular diminution of heat had steadily proceeded from the Mesozoic on, until, in the later Tertiary, moderately sharp winters like those of the present temperate zone ruled in the north polar area, which at this critical juncture presumably took on for the first time in its history the land-locked condition and rigorous Arctic climate such as we see to-day. Then simultaneously, possibly with a brief period of low solar radiation, maximum obliquity of the ecliptic, a highly eccentric orbit, changed position of the Gulf Stream, and also mayhap the emergence of boreal mountains, the glacial period set in. But whether or not this was preceded after the same manner by an earlier Miocene glaciation is a topic I shall not need to take up.

The fundamentally important point is, that extensive Arctic explorations taken together with the fossil plant record, preclude glacial periods in the north polar area previous to Miocene time. And as we go back in time, periods of high eccentricity with changed position of the ocean currents and areas of barometric pressure, tended less and less to produce glaciation at either pole. *They must rather have resulted in prolonged hot, or frosty, or cool, or rainy, or dry seasons.* Each return of high eccentricity thus witnessed, speaking comparatively of the general or average conditions of the epoch in which it occurred, the most profound climatal modifications, these always being greatest at the poles and diminishing toward the equatorial regions where they would be scarcely felt. As eccentricity is always fluctuating with a tolerable frequency of maximum periods, and as these always last long enough for equinoctial precession to reverse the maximum effects, the polar areas have hence been throughout geological time the scene of a steadily increasing and finally stupendous shuttle of climatic change.

Nor need we, so far as the main question is concerned, carry this general statement further. It does not affect, unless in its favor, the force of the present argument, for instance, that there is increasingly abundant evidence of Permian glaciation in the southern hemisphere. The fact is that in the north all the known evidence is against pre-Miocene glacial epochs and in favor of mild climates throughout the early Tertiary, and of more and more tropical climates in all of the Mesozoic and

Paleozoic, though subject throughout, let it be repeated, to the shuttle of seasonal change due to orbital eccentricity. But let us now turn to the biologic record.

Theoretical early polar life, and the generalized conditions of the Paleozoic.—If it were permissible to accept the suggestion made by Chamberlain* and others that the early history of the globe was mainly one of quiet meteoric aggregation without the fusion of all its mass at any time, the period during which the origin, or introduction, of life could have taken place might be considered as greatly lengthened, and extending back into very novel conditions. But although this idea may have very important elements of truth in it, it is one requiring much further elaboration, and as we shall see need not here be taken up. The hypothesis of the early nebular constitution of the solar system and of the molten globe, as formulated by Kant and by Laplace, and as supported by most of the every-day facts of geology, astronomy, physics, and chemistry, as well as rigid mathematical interpretation, must as yet afford the main basis of speculation. One cannot but admire the confidence with which Lord Kelvin speaks of the first formed crust of the molten globe a few centimeters thick, and says that, "All the reckonings of the history of the underground heat . . . . are founded on the very sure assumption that the material of our present very solid earth all round its surface was at one time a white-hot liquid."

Now in the face of concrete facts, bare suggestions to the contrary cannot have a very great weight. If the molten globe is to be accepted as a reality, it is then clear that perhaps in part owing to the equatorial bulge, but mainly because heavy tides and currents must long have continued to break up the initially formed crust in the equatorial regions, there must first have appeared at the poles sufficient crustal stability to make hot water life possible. It is also to be recalled that as strongly indicated by G. H. Darwin's hypothesis, the moon must have been at this early period much closer to the globe than now. If so there must long have been produced lunar tides of tremendous power sufficient to break up crusts of many meters in thickness in the equatorial regions, while at the pole weak tides would rule. A great interval of time must then have elapsed between the first appearance of crustal stability at the poles and at the equator, an interval of time enough for the formation all round an undisturbed molten globe of a crust a sufficient number of meters in thickness to resist the lunar and solar tidal stress. This length of time between the appearance of stable conditions suitable to the

* On Lord Kelvin's address on the Age of the Earth as an abode fitted for life. Annual Report Smithsonian Institution, 1899.

lower forms of life at the poles and their later appearance at the tropics would also be lengthened by the greater heating power of the sun at the equator, a factor doubtless greater then than now. In any case the critical temperature and the stability necessary even to hot water life may well have required a million years to slowly move southward to the equator, after an initial appearance at the poles. And the highly interesting view that the requisite physical conditions of life did actually first appear and inaugurate life itself at the north pole, and that as the result of evolution in the northern circum-polar area new species were continually dispersing from thence southward throughout time down to the glacial period, was ably presented by Mr. G. Hilton Scribner, more than twenty years ago.* When Mr. Scribner wrote, the work of G. H. Darwin had not yet appeared, and while overlooking the part that tides must have played in preventing equatorial stability and thus have been the main factor in preventing early equatorial life, his chief conclusion is regarded as fundamentally correct, and to him belongs the credit of its first enunciation. Though it seems quite clear that life could as reasonably have had a similar beginning at much the same time at both the poles.

The causation of this assumed early polar origin of life, has of course a direct bearing on the view of climate here presented. But without indulging at present in speculations however interesting, I shall only say in passing that we cannot admit that the properties of primal protoplasm, whether of mundane or extra-mundane origin, depend on anything else than the physical, electrical, chemical, *vital* and other properties of matter. "*Ex nihilo nihil fit.*"†

* Where Did Life Begin? New York: Charles Scribner's Sons, 1883.

† The theory that the origin and entire course of life is wholly based on the properties of matter must be held as the most comprehensible, even if life was actually transplanted from some other sphere, for thus pushing its origin back a stage leaves us in precisely the same position as before. But that life may have originated very remotely and have reached this globe, perchance, from other celestial bodies is not utterly without the bounds of reason, as suggested by the experiments of Professor Dewar and Sir W. T. Thiselton-Dyer, showing that seeds (and spores) have wonderful resistant power to cold. These experimenters placed the seeds of flowering plants in vacuo at −250° to −253° C., a condition approximating outer space, without greatly affecting their vitality,—a good proportion of the seeds which had been thus passed through a sub-crystalline state afterward growing when planted. Other seeds were soaked in liquid hydrogen and afterward germinated, as did yet others after immersion in liquid air contained in a red hot platinum dish!

It is above all things conceivable in the light of such experiments that virile spores and resting stages of lowly organized forms may have reached this globe from the outer space at any time in its history, or indeed may still be reaching it for aught we can say, in the vastest numbers. The "red

With regard to the period of an assumed polar origin or implantation of life, needless to say little can be said from the purely historical view in so far as now known. In general the all sufficient assumption is that consolidation of the continents went on apace, and that there was a continuous dispersion of increasingly diverse forms from the slowly enlarging and more equable polar areas towards the borders of the lessening tropical belt over-hot for life. *Even though the globe was never in the white hot condition*, this was still doubtless the case, and the presumption is strong that coupled with eccentricity the same progressive climatic changes already mentioned played their part even in the ancient period, culminating in the universal tropical conditions of the Paleozoic to which the unimpeachable geophysical and paleontological record carries us back. But it is, of course, not possible to now trace out the actual march of events in the Paleozoic, abundant though its fossil forms may be. It may only be remarked that the great preponderance of aquatic animals and spore-bearing plants made the distribution of Paleozoic life easy, and rapid, and general, facts which aside from the scanter record render it very difficult to reach conclusions concerning any invasion of polar forms so far as recorded in fossil floræ and faunæ.*

In general it may be said that in the Devonian and Lower Carboniferous most plant forms are, so far as present, more or less ubiquitous. During these periods the Equisetales, Lycopodiales, Filicales, Sphenophyllales, Cycadofilices, and Cordaitales appear to reach a high degree of specialization and for the greater part a cosmopolitan distribution. These generalized floral conditions were, however, interrupted in the Permo-Carboniferous by the appearance in the southern hemisphere, mainly below the tropic of Capricorn, of a new and simpler type of flora than that continuing to flourish and develop in

snow" (*Sphærella nivalis*) of the Arctic regions shows us that in the old worn out and frigid stage of a planet life may still be present.

The life of hot springs affords an example of low organization at the opposite temperature extreme.

* It is true that many large seeded plants existed, but their seeds would readily be carried from island to island, when not too distant, bearing in mind the much freer circulation of ocean drift among the Paleozoic islands. An excellent example of the ease with which the ferns make their way is afforded by the isolated occurrence of *Adiantum Cappillis Veneris* along a stream fed by thermal waters in the Southern Black Hills, far beyond its utmost normal north-limit. This shows how readily spore-bearing plants transplant themselves to great distances and to strange places. Nor may the new station for the "Adder's Tongue," *Ophioglossum Vulgatum*, recently found in Iceland, mean that at this point a last stand is being made against the cold that has driven this fern from its original boreal home, but just as readily that it has long since during glacial times been pressed far to the south, and that its spores have again been wafted northward from either Eurasia or America.

the north—the so-called *Glossopteris*—flora. In this the genus *Glossopteris* was so extraordinarily abundant as to have suggested to Seward in his eloquent presidential address* the idea that it must have monopolized wide areas over large parts of southern South America, Africa, and Australia to the exclusion of other plants, just as the Bracken to-day covers sunny hillsides with a carpet of green. The southern origin of the *Glossopteris* flora is certainly a legitimate assumption, and was doubtless connected in some way with climatic changes culminating in the glacial conditions of the southern Permian. But whilst the *Glossopteris* flora in reality thus furnishes the first suggestion of the breaking up of ancient generalized tropical conditions by an invasion from the far south, there remains the fact of the immense extent and distribution of more varied northern forms, as well as the return and long persistence of wide-spread uniform conditions during the Trias and Jura. The vertebrates of the later Paleozoic are not as yet understood to indicate any differentiation into zoological realms, although a much fuller knowledge of the Permian faunas of Texas, South Africa, and Northern Russia may yet furnish evidence of such.

Although doubtless increasing in force, polar influences due to eccentricity during Paleozoic time must hence from the nature of the record long or always remain more or less obscure. It is, however, from this period on that the facts of polar origins become clearer and clearer. As soon as we get in the Mesozoic, the fortuitous combination of fairly numerous freshwater strata on the Continental mainlands and the early representatives of the more highly organized vertebrates and plants, which by reason of their organization are easily liable to displacement and extinction, and hence constitute delicate horizon-markers, we become more and more aware of a vast procession of similar series of both animals and plants from north to south on both sides of the Atlantic. To this main line of our discussion let us now yield attention.

The Argument for Polar Origins as Based on the Vertebrates.—The earlier expression of the north to south movement of types originating in the high north consists in the fact that the small and delicate so-called mammals of the Jurassic are much alike in beds on both sides of the Atlantic presumed to be of about the same age. In the Cretaceous the same general fact is true, but in an accentuated form. And throughout the Tertiary the completer the record the greater the parallelism displayed between synchronous faunæ of the various European and American horizons yielding vertebrate fossils.

* British A. A. S. meeting at Southport, 1903, Address to the Botanical Section.

Now all the divisions of the Tertiary, the Eocene, Oligocene, Miocene, and Pliocene were markedly periods of great inland lakes and flood plains, which on the whole favored the deposition of far more extensive freshwater beds than those of earlier times when the continents were rather smaller. Moreover, these periods witnessed the expansion of the primitive mammalian stocks into the existing mammalian orders, as well as the rise and extinction of many striking forms. As a consequence, the mammals being from size, habit, and frequency of preservation among the best of all horizon-markers, the Tertiary record, unlike the older and more imperfect Mesozoic record, is often quite complete. The North American Tertiary strata are more than a mile in total thickness, and contain imbedded at intervals, which of course depended on local conditions, a score or more of successive faunæ. When closely studied these are found to possess many peculiarities of their own. Many of the genera and families of each are new and unheralded in preceding groups. No vertebrate paleontologist would consider these new elements as direct local derivatives from preceding faunæ. That is to say, there is throughout the series an ever-recurring lack of precursor forms, if we except the later stages of certain groups like the horses which evolved many successive species in the great mid and late Tertiary American plains. In short, most of the groups come suddenly with a large proportion of new elements scarcely or not at all related to preceding forms and they go as suddenly, as if by a succession of "waves" or "impulses." In Europe there are not such extensive Tertiary deposits as in America, but there is a reasonably complete record, and it shows the same history of new faunal influxes. But this is not all. The series of unheralded faunal influxes forming so prominent a feature in the European Tertiary was made up of much the same successive elements, possessing the same peculiarities as well as many of the same genera and closely related species, and appearing in the same order, and at essentially the same time as in America. In fact, essentially the same new complex faunæ appear, as explained, at about the same time on both sides of the Atlantic so often and so continuously as to make this mode of appearance the rule, not the exception. And such differences as do present themselves are explicable on the basis of the known great imperfections of the fossil record, on some climatal differences, and because of the unlikelihood that all the elements of faunæ, including diverse orders and families, could in any case whatsoever reach such widely separated regions.*

* These facts of similarity become more and more striking with exacter methods of study and the multiplication of known forms with each added year of exploration. Thus Charles Depéret in a recent study of the *early*

How best explain this extensive faunal parallelism? As the deep oceans and the continents, though slowly increasing in area as the result mainly of delta formation, have occupied relatively the same position as now far back in geological time, there have been no means of horizontal dispersion back and forth. Although this view has been at times called into requisition it appears to be utterly unsound. The great antiquity of the principal elements of the life of the Hawaiian Islands, Australia, New Zealand, Madagascar, bears unmistakable testimony to the difficulty of dispersion of the higher types of life across ocean barriers in any direction, and indeed shows such dispersion of the vertebrates to be nearly impossible. Nor is it conceivable that there was a *constant* exchange of American and European monkeys, ganodents, cumbrous ungulates, horses, dogs, rodents, bears, etc., etc., back and forth by way of the polar regions. The difficulties of the enormous distances, doubtless in most of Tertiary time increased by mountain ranges, of the Behring's Strait, or the Aleutian Island route, for such interchange between the Tertiary basins of Wyoming and France are obvious enough. The shortest nearly all land route that may by any possibility have existed so nearly as may be judged from present shallow ocean depths, would have been by way of the transverse submarine plateau marked by Iceland, the Faeroes, and Shetlands, the average depth between these islands, exclusive of the deep waters off the Greenland coast, now being some 250 fathoms. The remaining possibility lies almost directly in line with the north pole and would be a route by way of Melville Peninsula and Cockburn Land, North Devon, Ellesmere Land, Grinnell Land, Melville Land, The Spitzbergen Group, and Franz Josef's Land, Nova Zembla and Northern Siberia. Even now this route involves but short water gaps. But even if conditions were more favorable than now, it is not conceivable that with the exception of a very few times in the past, if ever, could animals have succeeded

horses (Revision des Formes Européenes de la Famille des Hyracotherides, Lyon, March, 1901) finds as the result of close analysis that *Eohippus* Marsh of the Wasatch is close to *Hyracotherium* Owen and to *Propachynolophus* Lemoine of the Suessonian, that *Protorohippus* Wortman from the Wind River is very similar to *Propalæotherium* Gervais and *Pachynolophus* Pomel, and that *Epihippus* and *Eohippus* Marsh are similar to *Lophiotherium* of Gervais. Depéret shows that the early horses of Europe are most closely allied to those of America in their successive evolutionary stages, or even identical, and Professor Osborn in speaking of this similarity says (Science, p. 674, April 24, 1903): "It is probably premature to establish generic identity between these American and European forms; but it is evident that the time is not far distant when such identity is likely to be established, unless we take the ground that the European and American forms were entirely independent in their evolution from the time of their first appearance." In Europe, as in America, it appears, however, that in the later history of the horses there was mainly an indigenous evolution of species.

in passing by either of these routes. At all times since the earliest Mesozoic either animals (or plants) in so doing would so repeatedly have been forced to change their mode of life and endure new conditions during the reproductive season, especially after sharp winters set in in the northern regions, that one must greatly doubt if any ever accomplished the journey after the later Cretaceous. Likewise that any of the synchronous similar faunæ or elements of faunæ could have come from the south is contrary to the evidence of the fossils themselves, and contrary to what we know of the general north to south movement of animals and plants as so fully and thoroughly demonstrated by Wallace in his Island Life. Again, that the same series of peculiar genera of horses, dogs, camels, etc., were constantly being evolved independently at widely separated points is preposterous.

Taken singly and collectively, the facts of Mesozoic and Tertiary vertebrate distribution in the northern hemisphere explain themselves satisfactorily on no other than the sole remaining hypothesis, namely, that of a common polar origin of the principal ancestral stocks, which then dispersed secondarily outwards in waves or impulses from the polar area and spread over America and Eurasia. The various high northern lands mentioned above then become, instead of mere migratory routes, centers of origin and a means of ready dispersion, the various stocks only passing out uniformly from them in the southward direction—that which always offered least resistance to migration and extension of habitat. In addition a large part of Northern Siberia may be included in this northern area so subject to change, since Cape Chelyuskin lies 600 miles north of the Arctic Circle, while many Tertiary islands must have existed that have since disappeared. It is all the while to be borne in mind that broken land areas at the north are likely to have been important factors in the faunal and floral changes there taking place.

It is to be added that it is not impossible, and even seemingly probable, that the Antarctic area represented a minor dispersion center facing the apices of the triangular continental masses whence certain peculiar elements of the South American, African and Australian faunæ may have originally sprung.

More recently a masterful résume of the facts relating to the impressive synchronous succession of similar vertebrate faunæ in Europe and America has been given by Dr. J. L. Wortman,* and to him belongs the merit of first having pointed out its great extent and bearing on the question of the polar origin of the main ancestral mammalian stocks. Although the

* Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum, this Journal, vols. xi–xv, 1901, 1903.

general idea was vaguely suggested by Saporta, and very definitely by Scribner twenty-five years since, it has never hitherto been seriously entertained, worked out, or applied by vertebrate paleontologists in their discussion of the distribution of fossil faunæ.

As here held because of the following reasons, the north polar area has since the Carboniferous been of relatively *more* importance in the origination of hardy stocks with strong invasive power, and which have mainly followed outwardly lines of longitude, the more readily because of the secular retreat southward of tropical conditions throughout long periods of time:

(*a*) The parallelism between the life of America and Eurasia is apparently greater than that of the more isolated continental areas of the far south—South Africa, Notogæa, and Neogæa.

(*b*) The great land masses lie about and project well within the Arctic area, and have, therefore, afforded the presumably wider geographic range.

(*c*) There is much reason to believe that the lands near the north pole were always much divided into islands and peninsulas, and were thus, as elsewhere explained, a more active scene of plant and animal change than even a much larger and more isolated body of land such as Antarctica may have been.

(*d*) It is reasonably certain that over a large portion of the Antarctic area the continuity of life was interrupted by glacial conditions in the Permian.

But the same physical and ethologic principles apply to both of the polar areas. And it is of much moment to the views here advanced that although the discovery of the first evidence of the ancient vertebrate and plant life of Antarctica is yet to be made, the former presence of abundant life within the austral area has at various times been suggested or claimed. A convenient summary of literature bearing on this subject has been given by A. E. Ortmann.* And Osborn† says very distinctly that, "One of the greatest triumphs of recent biological investigation is the concurrence of botanical, zoological, and paleontological testimony in the reconstruction of a great southern continent to which the name Antarctica has been given."

The discovery of the great horned turtle *Miolania* in Patagonia, Australia, and Lord Howe Island, and as yet nowhere else, is only one of various striking facts that do suggest a former south polar land connection of these now widely separated localities. But not to tarry too long, I shall only remark that the views of Antarctica have come to be much involved

* Am. Nat., vol. xxxv, No. 410, Feb., 1901.

† Ann. New York Acad. Sci., No. 1, pp. 1 to 72, July 31, 1900.

with a belief in extensive lateral intermingling of African, Notogæan and Neogæan life. Crossing and recrossing of either of the polar areas we believe rarely to have taken place, and certainly during periods of polar cold this becomes quite, or wholly impossible.

Now it follows from *a priori* reasons, that since vertebrate stocks originated more and more frequently in the boreal area as time went on, down to the Glacial epoch, there must have been a preceding development of food plants of quite as varied character as the animals themselves, and with one more word we may turn to the plant record. Nothing could at the present time be more satisfactory to paleontologists than the discovery of polar localities yielding fossil vertebrates. As justly remarked by Professor Nathorst in a letter to the writer, "It is very curious that not a single mammalian bone has hitherto been found in any Tertiary deposit within the Arctic area." But this dearth of actual evidence is quite as much due to the unfavorable conditions for the preservation of fossil bones on the exposed surfaces in high latitudes as enumerated by Nordenskjöld and Palander, as to the lack of exploration. One cannot but believe that in the course of time there must be found in the high north evidence in abundance complementary to that of the Jurassic, Cretaceous and Tertiary vertebrate-yielding horizons of America and Eurasia.

The Argument for Polar Origins as Based on the Plants.—In the case of the plants there is both a northern and continental record. Both taken together supplement and confirm the evidence afforded by the vertebrates of the radiation of hardy stocks from the polar area on a grand scale. Indeed it is on the basis of the facts afforded by both the past and present distribution of plants, that more or less well defended theories as to the northern origin of the present temperate flora, and, *a priori*, fauna have from time to time been proposed. A belief in a Scandinavian flora of great antiquity, occupying the polar area and *during the advent of the glacial period* radiating out on every longitude and to every latitude, was held by Forbes and Darwin fifty years ago. It was given a certain basis in fact by Sir Joseph D. Hooker in his Outlines of the Distribution of Arctic Plants in 1861, and later on Saporta in the *Revue de Deux Mondes* (1883), after the discovery of the Cretaceous Arctic fossil floræ, stated his belief in the Arctic origin of the main groups of animals and plants far back in geological time, and including man as well. The definite conception, well fortified by facts, of a universal southward dispersion of plants from the northern polar area during Tertiary time was, however, first conclusively formulated and presented by Asa Gray in his Dubuque Presidential Address before

the Botanical Society of America in 1875. In 1883 additional facts were given by Mr. G. Hilton Scribner, who took up the subject from the standpoint of the northern origin of life itself. Moreover, in 1883 Nathorst published a map of fossil Tertiary plant localities in the north polar regions and the hypothetical routes of their migration southwards.

As we have already seen, the point at which the evidence from the side of the vertebrates is most wanting, lies in the entire absence of known vertebrate-bearing horizons within the polar circles, whilst, on the other hand, the American and European record is quite complete in Tertiary time, there being abundant horizons covering this period of rapid mammalian development. Contrariwise in the case of the plants, the northern record from the Cretaceous on, is one of the most interesting within the ken of the paleobotanist. But as the main development of the early Dicotyls and other plants constituting the best horizon markers took place in the late Jurassic, at a time when there is a considerable dearth of freshwater beds in close succession, the plant record also has its serious weak point. The general facts of both records are, however, so entirely complementary that it is a matter of some surprise that they have so little occupied the attention of biologists.

The fact that, as recently shown by Seward,* there are striking similarities in the plants of the Inferior Oölite of Yorkshire, and those of the lower Jurassic of Bornholm (Sweden), Japan, and the Rajmahal series of India, may, so far as present knowledge goes, be considered an early indication of a north to south movement of plants. It is noteworthy that *Gingko* and *Baiera*, so abundant in the Lower Jurassic of England, Japan, and Bornholm, are so far unknown in this horizon in India. Few forms, albeit, have a more striking northern development during Jurassic and Cretaceous time than the Gingkoales.

Following the period of very generalized tropical conditions, the earliest extensive comparison of European and American floræ that can now be made is that between the Jurassic of Portugal and the Trias of America. Notwithstanding this time hiatus, about two-thirds of the Portuguese genera, as has been pointed out by Ward, are present in the American Trias. In the Lower Cretaceous of Maryland and of Portugal the comparison is a much more striking one. There are, indeed, some species of wide distribution common to both. But as Professor Ward has said, "We should not, of course, expect the species to be common to any great extent, and the comparison is practically limited to the genera. Looked at from this point of view, we see that the resemblance is indeed close,

* Occurrence of Dictyozamites in England, with remarks on European and Eastern Mesozoic Floras, Quart. Jour. Geol. Soc., May, 1903, vol. lix.

a great number of the important genera occurring in both floras. There are no less than forty-six of these common to the two, though in some cases the author's individuality is probably alone responsible for slight differences in the names. For example, forms referred to *Baiera* by one would be referred to *Baieropsis* by another, and so with *Ctenis* and *Ctenidium*, *Myrsine* and *Myrsinophyllum*, *Oleandra* and *Oleandridium*, *Salix* and *Saliciphyllum*, *Thuya*, and *Thujites*, etc."*

Moreover, Professor Ward finds that the proportion of species of the similar genera bears some relation to the relative size of the two floræ, about 1 to 4 (200 species being known from Portugal to about 800 in Maryland). Thus the proportion of Portuguese to American species is respectively for the genus *Aralia* 2 to 11, for *Brachyphyllum* 5 to 9, for *Cladophlebis* 12 to 25, for *Frenelopsis* 2 to 6, for *Laurus* 3 to 8, for *Myrica* 2 to 11, for *Podozamites* 7 to 15, for *Sphenolepedium* 3 to 9, etc. Of Magnolia, however, there is only 1 species to 12 in Portugal. Professor Ward concludes that, "On the whole it may be considered that the Lower Cretaceous flora of Portugal is, botanically speaking, a very close repetition of that of America; and in view of the fact that in both countries a number of distinct horizons showing the progressive change in the flora throughout that period have yielded fossil plants in such a way that, if the Portuguese beds were as fully developed as are the American ones, each of these florules might be compared, the subject becomes rather fascinating."

To note further the parallelism between continental floræ of Europe and America from the Cretaceous on, is scarcely required. It may be remarked that previous to the discovery of the rich Potomac flora and of various archetypal dicotyls in certain Jurassic strata it was supposed that the Angiosperms, now the predominant type of vegetation, had their origin in the Middle Cretaceous. The sudden and simultaneous appearance at this time in large number of species in Europe and America of the main forest types of to-day with but few forerunners, however, constitutes such a profound phenomenon of American and Eurasian plant parallelism as is scarcely explicable on the basis of lateral distribution. Furthermore, there is indicated a steady decline in temperature and retreat of tropical conditions to the southward. The Dakotas and Wyoming still enjoyed Floridian conditions in the Eocene. From this time on the temperature decline was marked.

But let us take a glance at the northern record. It is of more than passing interest to note that it so happens that the most varied Upper Devonian flora yet discovered is that of the

* XVIth Ann. Rep. U. S. Geol. Survey, 1894–95, pp. 469–540.

Bear Island which lies in 74° north latitude about midway between the North Cape and Spitzbergen. To be exact, it includes, according to Nathorst,* Filices, Sphenophyllales (extinct plants from which have been derived the horsetails and lycopods), Calamites and Lycopods. These plants indicate, needless to say, a decidedly tropical climate, and from their diversity of form and structure "show that vascular plants must have existed for an exceedingly long period previous to Upper Devonian time." As stated above, up to and including this period and the Lower Carboniferous the *Paleozoic represents a generalized tropical period in so far as can now be determined.* Nor is there reason to believe that other than tropical conditions ruled at the north during the Permo-Carboniferous and Trias. Likewise the Jurassic plants from Spitzbergen, King Charles' Island, Franz Josef's Land, Cape Flora, and other far northern localities leave no question of the continuance of these conditions within the Arctic area. Regarding the late Jurassic and the very earliest Cretaceous, or the period covering the origin of the Dicotyls, we as yet have scanty evidence from the north. But from this time on the record of climatic change furnished by the northern plants becomes a striking one indeed.

Greenland is one of the best known of Arctic lands. Though largely an Archaean area of eruptive rocks much too old to shed any light on the character of ancient northern life, and intensely scoured and glaciated, this winter-locked land affords abundant and reasonably connected evidence of the slow decline in temperature that culminated in the Glacial epoch, as well as of the exceedingly rich and varied flora that just preceded this period of decline. About the edges of the great ice cap far to the north on the west coast, and mainly between 69″ 15′, and 72° 15′ N. L. there are numerous outcrops of Sandstone and slate containing intervening layers of coal, clay, and clay ironstone, from which have been obtained some of the finest series of Cretaceous and Tertiary fossil plants known, the best and most numerous localities being on the peninsulas of Nugsuak and Svartenhuk, and on Disco Island. The most northerly locality is in Grinnell Land, 82° N. L. These plant-bearing beds have a total thickness of from 2,000 to 3,000 feet, and are covered by an additional 2,500 feet of basalt, which has protected them from erosion by superimposed ice. Being loose of texture, it is held that they would certainly long since have been completely eroded away were it not for this basalt covering. Although known for nearly a hundred years, the first adequate collections of fossils from these plant beds were made by

* Zur Fossilen Flora der Polarländer, Erster Teil. Dritte Lieferung. Zur Oberdevonischen Flora der Bären-Insel. Stockholm, 1902.

Nordenskiöld and Steenstrup, and studied by Professor Oswald Heer, the chief results being published in his magnificent monograph the *Flora Fossilis Arctica.*

Heer divided the Greenland beds into (1) the *Kome beds*, (2) the *Atane beds*, (3) the *Patoot beds* and (4) the *Tertiary beds.* In all there occur more than 600 species of plants.

In the lower or *Kome beds* (the so-called Greenland Urgonian), twenty or more Cycads, as many Conifers, a number of ferns, five Monocotyls, and one Dicotyl are present. The Cycads are mainly of a quite modern type and also include a species close to *Cycas revoluta*, now native of warmer Japan, but are almost uniformly dwarfish forms. The conifers, sequoias, and pines seem to have formed extensive forests. The single Dicotyl (*Populas primaeva*) was regarded as the oldest of all the dicotyls until the later discovery of primitive dicotyledonous types in the lower Cretaceous of Maryland and Portugal, to be again mentioned. Heer concluded that the mean temperature when the Kome beds were laid down was about 71° to 72°. This is that of Cuba now.*

In number (2) the *Atane beds* there occur at Lower Atanikerdluk more than fifty Dicotyls, including the fig and the bay. There are fewer ferns and a diminishing number of conifers, and the presence in this much changed floral facies of about four Cycads shows them to be a waning group, although no other than very slight decline in temperature is indicated. In (3) the *Patoot beds* the Dicotyls reach a fully established sway, numbering about 70 species with 18 conifers, whilst the Cycads disappear. Oaks and planes are here the most abundant forest trees, and alders, maples, figs, bay, walnuts and birches are present. A secular decline in temperature is indicated. In all these floræ a noteworthy phenomenon often noted amongst Upper Cretaceous plants and eloquent of the origin of the Dicotyls in a moist and hot climate, is the growth side by side of forms whose nearest relatives are now found quite exclusively in either temperate, warm temperate or hot climates. Thus in the Atane beds the bread fruit tree, now only found in the hotter lands, grew side by side with the oak and chestnut.

The Greenland *Tertiary* includes twenty beds containing

* A quite similar climate and forest facies is indicated by the fossils of the "Lower Cretaceous" cycad-bearing horizons of the Black Hills "rim," where large numbers of cycads, possibly in part of a somewhat older general type than those of the Kome beds, formed the underbrush or grew in the open dells of great coniferous (Araucarian) forests. The beautifully silicified trunks with the leaves and fruits of the Bennettitalean cycads and numerous immense Araucarian silicified logs as well as many plant impressions tell the story. It is significant that here as elsewhere the sway of the gymnosperms was very suddenly disputed by the inrush of Angiosperms, with but very few precursor forms.

Eocene and probably Miocene plants, represented by nearly three hundred species. The conifers, Taxodium, Thuja, Sequoia, Gingko, Abies and Pinus are present. Among the Dicotyls are a profusion of oaks and walnuts, with poplars, elms, ashes, planes, maples, chestnuts, alders, beeches, birches. There are, moreover, bays, six species of magnolia, three of ebony, and a soapberry, as well as smilax and other climbing vines. Heer considered the mean temperature indicated by these plants of northern Greenland to have been not less than 55° F.; though Professor Nathorst, the most distinguished living authority on the plants of the polar lands, shows this estimate to be certainly too high for the close of the period, which was, however, warm enough for the ripening of walnuts in 70° 25′ N. L. Moreover, by this time fairly sharp polar winters had set in. Supplementary evidence showing this steady decline in Arctic Tertiary temperature has accumulated from a series of localities fairly girdling the pole. The principal ones are the Sabine Island on the east coast of Greenland, Iceland, Spitzbergen and the new Siberian Islands.

In brief the north polar regions were as yet markedly tropical in Jurassic time, and less so by the close of the Cretaceous; whilst the several northern fossil floræ indicate a steady, persistent, unmistakable secular decline in temperature over the entire polar area, culminating in the late Tertiary in arctic conditions.

That the rich vegetation of the various horizons represented within the Arctic area forms the original source of most of the plant families, which as the evidence shows spread synchronously over Eurasia and America throughout Cretaceous and Tertiary time, is a conclusion which we can scarce escape. But as to the actual first home of the Dicotyls it would of course on the basis of present knowledge be a gratuitous guess to say that this was within the Arctic circle. They may rather be a legacy left over from the later generalized tropical periods, these being characterized, as stated, by easy distribution. The first Mono- and Dicotyls may hence never be assigned to any particular region.

It is, however, to be observed that the early Angiosperms, which appear alike unheralded in the Cretaceous of Maryland and Portugal, may really be younger than the plants of the Greenland Urgonian (Kome beds). I only need note that the belief in the similar age of these beds rests entirely on floral evidence, and that equivalent floræ in such widely separated localities afford very insufficient proof of synchronism. Moreover, in view of what we now know of southern migrations if in the case of two quite similar but widely distant fossil faunæ or floræ, one rests far to the north, it is likely, once the strati-

graphic succession is learned in more detail, to be found overlapped and the more ancient. And, conversely, in the case of two such remarkably similar floræ as are found at essentially the same latitude in the Lower Cretaceous of Portugal and Maryland, there is a strong likelihood that they are really of much the same age.

Reasons for the Origin of Prepotent Northern Stocks.—As has been seen, the fact of extensive southern migration for long periods of time is a patent one. It now remains to take up the most interesting enquiry as to why hardy stocks originate at the north, and especially as to how their origin has been governed by the secular decrease in temperature which northern life shows to have taken place, as well as by the shuttle of climatic change, caused by orbital eccentricity, doubtless the most active of all factors producing change in the life of the polar areas. It is trite to say that the enquiry here briefly taken up must largely await future study, involving as it does the fundamental working principles of evolution. But it is possible to mention certain salient elements of the completer answer.

Vegetal and animal forms are often figuratively spoken of as driven south, or east, or west. Now forms of life may be driven out of a region, that is exterminated within its bounds, but unless rarely, in the case of the more intelligent higher forms of animals fleeing from some newly appearing dreaded enemy, they are never actually driven into a new habitat. Nor do they migrate except in a most general sense. They simply make their way aided by or in spite of vicissitudes of climate and season, as if from one side of a stream or one hillside to another, changing more or less all the while, while somewhere to the rear the original stock is also changing into a new one or being directly cut off.

Again the conditions under which the life of a given locality thrives are always in the long run retreating southward, and other and hardier forms are always to be found to the northward, though in less and less number as the secular approach of glacial cold slowly and surely depopulated the Arctic area. Now, only the hardy remnant of the once abundant northern life yet dwelling on the borders of the great ice cap is left. But it is a remnant with the power to invade, and that is still pressing south in the same manner as the more profuse boreal life of the past. Hence, as secular cooling is always going on, and as the general nature of growth is constant, a condition of high northern organic potential resulting in a southward stress and movement must always exist.

The idea here meant to be conveyed can be readily illus-

trated. According to C. Hart Merriam* nine species of plants brought back from Lady Franklin Bay by Lieut. Greely also occur on the bleak and storm beaten summit of San Francisco Mountain in Arizona, hundreds of miles south of any other known station.† These plants grow at an altitude of 3,500 meters and their seeds were either carried southward by birds, or they are a far southern remnant of a once wider habitat during glacial times, which is more probable. Beneath the summit where these isolated species grow are found on a small scale successive realms of animals and plants recapitulating in a way the great life belts that can be distinguished in passing from the mountain base to the Arctic Ocean. Now it is very clear that in the event of secular or perchance local decrease in temperature the Arctic forms at the top of San Francisco Mountain would immediately step into the places left vacant down the slopes by killing or weakening frost. Conversely, if melior conditions were to begin from any cause to rule at the summit, owing to increased seasonal heat or dryness, overlapping especially the reproductive season, or for other causes, this far southern skirmish line of the advancing northern flora would doubtless be beaten back or destroyed. Every agriculturist knows this principle and avails himself of it. Experience has everywhere taught that for any given locality northern varieties of plants (and animals) are the hardier, and that southern stocks are weaker and even impossible of successful introduction. Hence for any given isotherm as viewed at the present time the maximum of easy conditions of growth always lies *somewhere to the south.* And it appears that among other effects, where forms of life do succeed in holding out against more and more stringent conditions there is especially a resulting increase of fertility, while on the other hand, where such forms after being inured to rigors are transplanted, or naturally make their way into far more favorable conditions, there results a more robust growth and a decrease in fertility. This would be one prime reason why the southward stress due to secular diminution in heat would be the more readily taken advantage of.

Evidently then from the record of the past, the vast majority of southern types are known to have made their way from the north, and at the same time the present organic facies and everyday knowledge shows that life utterly fails to make its way northward again and that southward stress is ever present.

* Biological survey of the San Francisco Mountains, U. S. Dept. of Agriculture. North Americau Faunæ. Bulletin No. 3, Washington, 1890.

† List of plants growing both on the shores of Lady Franklin Bay, and at the summit of San Francisco Mountain, Arizona:

Androsace septentrionalis; Arenaria verna; Cerastium alpinum; Cystopteris fragilis; Saxifraga caespitosa; Saxifraga nivolis; Oxyna digyna; Trisetum subspicatum.

But whilst the constant changes in animal and plant forms, due to the operation of such causes as these, are fairly apparent, the subject of the vicissitudes of the southern movement of life "as it takes its way along the great north and south rivers and is split by the great north and south mountains" of America and Eurasia, is a fairly separate topic. What is plain is that there is and has been a constant stress due to northern prepotency extending all the way to the pole itself, where, as has been repeatedly stated, climatic variation has always been relatively greatest. And this brings us to the consideration of what the mere determination of the nature of the southward organic stress scarcely explains, that is to say to the crux of the entire question, the reason *why* prepotent races tended so constantly to originate at the north. Nor can I hope adequately to deal with this feature of the present subject. However, the ordinary physical environment and the far reaching effects of climatic conditions considered of course in their widest sense, and including in a largely unexplained manner electrical conditions, are the sole and the only evolutionary factors influencing life as such, within the range of my vision.*

From such a view-point quite the first of the elements of polar climate that occurs to me is the peculiar distribution of light. Well might J. W. Dawson, who was not an evolutionist, say in remarking on the varied northern floræ and the fact that the flora of Canada, where growth is arrested by cold nearly six months in the year, is in some respects richer than that of temperate Europe, that,—†

"It is indeed, not impossible that in the plans of the Creator the continuous summer sun of the Arctic regions may have been made the means of the introduction *or at least for the rapid growth and multiplication of new and more varied types of plants.*" The italics are mine. But we have a fund of facts directly bearing on how much of this growth of new species was thus produced, without any extraneous interference

* I am glad that but recently so powerful a thinker as Ward has not hesitated to thus define his view of bathmism—" . . . Motility (or the power of spontaneous molar motion which is the differential attribute of life) in its later stages takes the form of bathmism, and becomes the universal growth force of the organic world. What I wish especially to emphasize here is that motility, with its generalized form, bathmism, is simply a property of protoplasm and of all living organizms, as much so as sweetness is a property of sugar, bitterness of quinine or isomerism of protein. *Zoism is a synthetic creation of chemism.*" (Pure Sociology, p. 115.) I take the liberty of underscoring the last sentence. A simple theory of life may best be founded on the idea of an atomic basis of consciousness as a true property of matter differing in degree in the several atoms just as the several chemical elements differ in their magnetic or their radiant powers, or in any of their *other* fundamental properties, none of which are definable except in terms of themselves.

† The Geological History of Plants, New York, 1888.

or direction other than that based on the properties of matter, including the power of living and undergoing evolution.

Kerner Von Marilaun performed various culture experiments in the powerful light of the Alpine heights of the Tyrol, and his conclusion from these is definite. He says:*

"From these culture experiments two things may be learned: first, that a very brilliant light is able to influence the distribution of plants, and to set up an impassable barrier for many of them; secondly, many plants have the capacity of adapting themselves to various degrees of light intensity, but in consequence they develop such a varying character that they might be mistaken for wholly distinct species." It also is known that certain species with the foliage exposed to the direct rays of the sun have violet or red hairy leaves, and that these same species growing in shady places may have green and nearly hairless leaves. Again, the leaves of one and the same species may have on low ground few hairs and thin cuticular layers, while on high mountains its leaves may be shrouded in thick grey or white fur and have a thick and leathery texture in consequence of strongly developed cuticular layers. And Kerner further states that herbs with vertically directed leaf surface are never to be met with in shady places. The leaves and branches of plants of vertical habit when brought into the shade tend to twist and bend so as to present a broader leaf surface to the diffuse light.

It is obvious that in temperate and tropic regions the vertical position of the young and tender leaves of such plants as the ferns and cycads, is a protection against strong sunlight. Later, when thick epidermal layers have formed, the leaf bends into its normal position and catches the nearly full rays of the sun. Curved young pinnules, like those of *Cycas*, also afford protection from the hot sun. From such facts, and they could be extensively added to, it is very clear that the peculiar light relations of the Arctic regions must always have had great influence on plant, and perforce on animal life. The further minor changes produced during southward migration could only be deduced from extended careful study. The range of light variation lies between the polar perihelion day or night of 200 solar days, and the equal division of twelve hours of daylight and twelve hours of darkness at the equator. When the greatest local variation in length of light succeeding darkness takes place within the Arctic circle, periods of vernation and reproduction must be more powerfully *altered* and *changed* there than elsewhere, reasoning from cause to effect. It would seem also that the hibernation of many animals, including certain forms of such diverse groups as monkeys, bears, and tur-

* Page 394 of Oliver's translation of Pflanzenleben.

tles, now living in tropic or subtropic regions, is a habit acquired in an original boreal home, and never broken.

As bearing on the general effect of light and darkness on plant growth, the elaborate experiments of MacDougal* are of high importance. He shows that etiolated tissues tend to remain in a primitive condition, though there may be transference of light effects to etiolated parts, that light shortens the meristematic period and induces the formation of permanent tissue, and that aplastic material is not so readily laid down in the absence of light. These facts are all suggestive of a chemico-physical basis of growth and development, and in complete accord with the ideas proposed here.

But with regard to the effect of the Arctic night on plants there have been probably no experiments in detail, although it is well known that the women of Disco Island find no difficulty in growing in their homes ornamental plants from far southern latitudes. If it were attempted, however, to demonstrate experimentally the effect of conditions representing hypothetical climates of the past, it would be necessary to use plants which have changed greatly and could therefore yield only relative results. Thus the entire cast of vegetation in the Carboniferous, of course conformed in transpiratory and other delicate functional structures to the moist hot climate, diffuse sunlight, and superabundance of carbonic acid characterizing that period. Hence while duplications of these climatic features may be readily made in the laboratory, their effect on plants now living affords only a general idea of the actual effect of the conditions of Carboniferous vegetation.†

As in the case of *light*, *heat* and *moisture* were also similarly variable to the utmost degree in the polar areas. Even if the

* Memoirs of the New York Bot. Garden, vol. 11, Jan. 20, 1903.

† A series of experiments, apparently requiring further extension—especially with reference to Pteridophytes,—has recently been made by H. F. Brown and F. Enscome (Proc. Roy. Soc., lxx, p. 397–413, pl. 5–10) to determine the probable effects of varying amounts of atmospheric carbon dioxide on the photosynthetic processes of leaves and on the mode of plant growth. These experimenters subjected plants during periods of several months to an artificially conditioned atmosphere containing as much as 11·47 per cent of carbon dioxide, and found that this resulted in diminished leaf surface, increased starch and chlorophyll content, deeper green, and various stem modifications. Fructification was apparently checked. Without attaching undue importance to experiments which leave many categories of inquiry unsatisfied, we may say that it is demonstrated that variations in the amount of atmospheric carbon dioxide do affect plant growth profoundly. And the effect on animals is equally or even greater, considered as either direct or indirect. At the poles, in addition to the direct chemical effect due to increase or decrease in the amount of atmospheric carbon dioxide, there is a further important physical effect. Dr Arrhenius (Philosophical Magazine, S. 15, vol. xli, No. 251, April, 1896, pp. 237–279) estimates that the addition of but two to three per cent of carbon dioxide to the atmosphere would be sufficient to give to the Arctic regions the genial climate indicated by their Tertiary flora.

north polar area had been at times in the past occupied by a continental mass with a but little broken shore line, the general statement that during periods of high eccentricity, this region underwent relatively more change in the distribution of seasonal heat and moisture than the inter-polar portions of the globe, could scarcely be challenged. But there is every reason to believe that the presence of numerous peninsulas and archipelagoes has long characterized the Arctic regions, and that these added very directly to the peculiarities and vicissitudes of northern climate, more especially, too, because of a doubtless not infrequent diversion, as change went on, of ocean currents. At times of high eccentricity there must have been within the limits of the time of the precession of the equinoxes, the most extraordinary changes and diversities in cloudiness, rainfall, dryness, heat and frostiness in the localities about the pole. As in the case of light these changes must have affected the economy of plants and animals profoundly. The possible difference of 36 solar days in the length of the seasons would in many cases produce totally different weather conditions during the periods of reproduction, sometimes favorable, sometimes adverse. Extermination must have been not infrequent, and likewise favorable turns of seasons. But it is scarcely necessary to go into these particular features of polar climate at great length now. This general statement may here suffice as the effect of varying conditions of light, heat and moisture on the lesser scale to be seen in temperate and tropic regions, and therefore their general significance must be fairly well understood. Aside from these factors it only need be remarked that there remain the more conjectural, magnetic, electrical and perhaps other effects included within the idea of climate as the resultant or manner of the terrestrial reception of radiant energy.

Perhaps the most fundamental corollary to the view of northern origins as now dealt with at some length, is that of a rapid origin of new species or even genera of both animals and plants. But the idea that this has been the general rule has been suggested, or even insisted upon by various naturalists. And this rapid origin is especially noteworthy in the vertebrata. The horse, I am told by an eminent authority, accomplished more evolution dnring the deposition of some 900 feet of John Day and White River Oligocene and Miocene sediments, than in all of previous Tertiary time as represented by far more than a mile of sediments. The same is in fact known to be true of so many vertebrate stocks that it may well be the rule. More recently Cumings in his able study of the Morphogenesis of *Platystrophia** has also found in the case

* This Journal, vol. xv, 1-48, 121-136, 1903.

of this exceedingly well represented brachiopod genus extending quite through the Cambrian, Ordovician and Silurian, that the fundamental difference between its earlier and later history "is the presence of intermediate groups during the former period, and their absence during the latter." In view of his own studies and the testimony of others a summation of the general facts is thus stated:—"Given a new and vigorous stock in a favorable environment, the initiation of new species takes place with great rapidity."

It may of course be added that by any "rapid" evolution I here mean only relatively rapid. Sudden changes of climate, or the transportation from warm to much colder localities and *vice versa*, result in very obvious changes in animals and plants, but such do not usually leave the stock a vigorous one, or end in extinction. I have described an excellent example of this kind in the case of the shutting out of salt water from the Currituck Sound by the closing up of the Currituck Inlet in North Carolina by drifting sands in 1828.* Previous to that year this inlet formed such a passage from the ocean through a narrow outer beach into the waters of Currituck Sound as is now formed by the new or Ocracock Inlet to Pamlico Sound. With the closing of the Currituck Inlet there resulted a conversion of upwards of one hundred square miles of shallow salt or brackish water to a fresh water area; and it is within the memory of men now living that the resultant changes in the life of the sound were immediate and striking. Previously the sound had been a valuable oyster bed. But within a few years after the exclusion of salt water the oysters had all died out, and their shells may now be seen in long heaps where they have been thrown out in dredging for a boat way in the shallow Coinjock Bay, a southwestern extension of the sound. Furthermore, the salt water fishes were driven out, and fresh water fishes took their places, whilst such changes were produced in the vegetation as brought countless thousands of ducks of species that had only been occasional before, thus making this one of the finest hunting grounds on the Atlantic Coast.

Owing to the landlocked condition of the Arctic area, and its numerous peninsulas and archipelagoes, such changes must from the Mesozoic on often have occurred there and by depopulation added to the general tendency to rapid change.

Some idea of the amount of evolution which may be undergone in isolated and favorable areas after a general dispersion has taken place, may be gained by the consideration of island life. The great development of tree-like plants, elsewhere

* This Journal, p. 76, July, 1897.

herbaceous, as seen in the arboreal lobelias, the shrubby geraniums, violets and plantains, and the strange arborescent Compositae of the Hawaiian Islands, affords an instructive example. But the evolution of the main groups of flowering plants having long since taken place, we cannot expect to find in islands, which at most show little more than such changes as have taken place in Tertiary time, evidence of the origin of new orders of plants; though such changes as are observed, or greater, doubtless often take place after the successful invasion of a new area, or in the case of the destruction of competitors in the old home. Moreover, if, as was always the case in the Arctic regions, the period of rigor was quickly followed by one of extremely favorable conditions coming on, nevertheless, at a rate easily taken advantage of by both plants and animals, races of great strength must quite surely be generated; and likewise new species, to an extent and with a rapidity that can scarcely be estimated on the basis of the fairly static conditions of most islands. As polar changes were mainly governed by the precession of the equinoxes, we know that the time scale was one of 12,934 years for the passing from rigorous to melior conditions and *vice versa*, throughout the successive periods of high eccentricity.

Summation.—From the preceding portions of the present consideration and argument, it appears that climatic changes of a character affecting life must in the course of time be of minimum amount at the equator, and increase towards the poles, where the maximum amount of such change occurs. Hence throughout time, the nearer a given locality to either pole, the greater the seasonal vicissitudes to which its life is subjected. Next, the view that the origin of life itself took place at the north (or at both of the poles), was accepted as in all probability the reasonable one, although as mentioned, the bare possibility that there has been a supplementary or an original extra-terrestrial origin of life also requires consideration. In either case, should the globe ever have been molten, the conditions making it probable that terrestrial life appeared at the poles, were not due alone to lesser solar heat there but mainly to the mechanical action of heavy lunar tides in the primitive equatorial lava seas. If the globe was never molten, any excessive equatorial heat whatever in the early geological periods would still leave the polar areas the probable early scene of life as at present understood. Attention was also called to the fact that the Paleozoic must have been because of climatic and other reasons, such as the freer circulation of oceanic waters, and the greater number of aquatic animals, and lowly organized or spore-bearing plants, a period mainly of generalized origins. Hence, there can be slight strati-

graphic record of the distributory movements of faunæ and floræ in the Paleozoic, although there are excellent reasons for supposing that even then polar climates were the most important of evolutionary factors. It would seem that from the origin of life down to the Mesozoic the north and south polar areas may have played a well nigh equal part in creating a certain southward and northward stress with, to borrow a term used in different sense by Ward (Pure Sociology), a sort of breaking up or *Karyokinetic origin* of species in the tropics. But beginning with Mesozoic time and extending to the glacial period, overwhelming evidence points to the polar origin and continuous outward dispersion from the north polar area of most of the great plant and vertebrate groups. Whatever minor rôle was played by the south polar area yet remains to be demonstrated. The successive unheralded synchronous appearance of in large part unrelated and complex northern faunæ, leaves us no other alternative hypothesis than that of boreal origin, in spite of the fact that vertebrate fossils of Mesozoic and post-Mesozoic age from the Arctic (and Antarctic) area are unknown. The similarity in successive unrelated and diverse faunæ synchronously appearing on both sides of the fairly permanent Atlantic, as the record shows, cannot be accounted for throughout long periods of time on the basis of lateral interchange. Nor can similar series of changes, and similar genera and even species have so often arisen independently at such widely separated points, as to have produced the parallelism so constantly evident in the fossil vertebrates of Eurasia and America. And these same principles apply to the record of the post-Paleozoic floræ as next reviewed and shown to be in all essentials the complement of the vertebrate record, and far completer. Further, it was recalled that the outward movement especially of Conifers and Dicotyls from the Arctic area for long periods of time, has frequently been recognized by scientists. Some of the traces of this movement are still evident in the present strikingly homogeneous circumboreal flora, although its main development, as in the case of the vertebrates, was obscured and partially checked by the appearance of glacial conditions.

Without attempting to follow out the several lines of evidence of northern origin and of southern migration and displacement any further, it does appear fully conclusive that all the factors of climate and therefore the main alternative potentialities producing organic evolution, have been in the highest degree variant in the polar areas. And this being true, the grouping of the continents about the north pole so that they have come to cover fully 300° of the Arctic circle would make it reasonable to suppose, were there not abundant direct evi-

dence pointing to the fact, that the northern circumpolar area has probably been, ever since the older Paleozoic at least, the main evolutionary center from which animal and plant life have radiated. But the theoretical view is as we see supported by overwhelming proof that such has been the fact, and that it is from the Arctic area that the greatest waves of change have swept out to lessen and disintegrate, though I do not at all mean to infer cease, in the more static conditions of the tropics.

The true nature of the southward organic stress was next illustrated, and some of the peculiar climatic conditions making the origin of new stocks more likely at the north were also pointed out. In particular I have also shown the possible connection between periods of high orbital eccentricity and the origination of the organic "waves or impulses" that students of the fossil record often speak of, or for which there is more or less conclusive evidence, especially among Tertiary vertebrates.

These cognate facts, as thus brought together, it seems to me sustain incontrovertibly our main thesis that polar climate has been the major factor in the evolution of plants and animals.

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Art. XLI.—*Note on the Composition of Bredig's Silver Hydrosols;* by J. C. Blake.

[Contributions from the Kent Chemical Lab. of Yale University.—CXXI.]

In preparing silver hydrosols by passing the electric spark between silver electrodes under water according to the method of Bredig,* it was noticed that the anode was eroded fully as much as the cathode, especially if the current passing was small (four ampères); and the freshly prepared liquid was always distinctly alkaline. The black deposit which at first settles out was dried at 105° or at 140°, and found to lose weight on ignition. The alkalinity of the liquid and the loss on ignition of the deposit were attributed to the presence of silver compounds, formed by oxidation of the anode. Some silver solutions obtained by the action of the current without sparking led to a confirmation of this belief.

Electrodes of specially purified silver consisting of plates $0{\cdot}5^{mm}$ thick and 3^{mm} wide, and of convenient length, as well as electrodes of silver wire obtained in the market, were immersed one or two centimeters in water from a tin still, or in "conductivity" water, and connected with the street current having a voltage of 110. On placing the silver electrodes in the water white and yellowish clouds seemed to arise from them and disseminate throughout the liquid, although the electrodes were some centimeters apart. This phenomenon, investigated in open vessels and in U-tubes plugged with asbestos, gave the following results:

Time. hrs.	Distance between electrodes. cm.	Erosion of anode. grm.	Conditions.
2	2 to 7	0·0821—	In an open vessel.
2	2	0·0692—	
2	2	0·0655—	In an open vessel, each electrode surrounded by a filter paper.
2	2	0·0149—	In a U-tube, electrodes separated by two loose asbestos plugs.
7	4	0·3107—	
3	3	0·0488—	In a U-tube, electrodes separated by two tight asbestos plugs.
9	3	0·0184—	

Throughout these experiments the cathode remained unchanged in weight, although a yellowish gray slime of

*Anorganische Fermente, Leipsig, 1901. Zeit. Angew. Chem., 1898, p. 951.

metallic silver collected on it, from which the yellowish clouds were derived; the anode at first gave rise to snow-white clouds (silver hydroxide?), but soon became coated with a brown-red layer of silver peroxide, whereupon the white clouds ceased to be evolved in appreciable amount. On one occasion, when the anode was nearly touching one of the asbestos plugs, a bridge of the snow-white material was formed between the anode and the asbestos. When the current was broken this band soon dissolved, leaving a skeleton of peroxide; but the white band re-formed when the circuit was closed again. The resulting solution was strongly alkaline at first, but became neutral by standing, doubtless because silver hydroxide was originally present in the solution and was changed to the carbonate by the carbon dioxide of the air. Part of the silver derived from the yellowish clouds remained in suspension, forming a hydrosol.* When alcohol is substituted for the water no action takes place without sparking and only the cathode is eroded with sparking, forming a black silver alcosol, thus strengthening the supposition that the erosion of the anode in the presence of water when the spark is not passing is due to oxidation. It would seem very likely, moreover, that the anode would be similarly oxidized while the spark is passing, not to mention the possibility that part of the finely-divided silver torn off from the cathode might also be oxidized when it is carried into the region of the anode.

In Bredig's method of preparing silver hydrosols by sparking between silver electrodes under water, the current is frequently stopped on account of the rapid erosion of the electrodes. During such intervals of stoppage the conditions are the same as in the experiments of which a description has just been given, excepting, possibly, the distance between the electrodes. It seems certain, therefore, that in Bredig's experiments silver compounds must have been formed, thus accounting for the facts mentioned in the opening paragraph of this note, and for the fact, noted by McIntosh,† that the electrical conductivity of the water is greatly increased by the process of sparking. It would seem essential that these facts should be taken into consideration in such extended investigations as the latter author has made on the catalytic properties of the finely-divided silver contained in hydrosols prepared according to Bredig's method, especially when working with neutral or acid solutions.

This inquiry was made at the suggestion of Prof. F. A. Gooch, to whom my thanks are due.

*Cf. Billitzer, Ber. Deutsch. chem. Ges., xxxv, 1929.
† Jour. Phys. Chem., vi, 15.

ART. XLII. — *Behavior of Red Colloidal Gold Solutions toward the Electric Current and toward Electrolytes;* by J. C. BLAKE.

[Contributions from the Kent Chemical Laboratory of Yale University—CXXII.]

I. *Behavior toward the Electric Current.*

IT is generally stated that colloidal gold solutions,* as well as permanent suspensions† and solutions of typical colloids, such as egg-albumen,‡ are coagulated and precipitated by the passage of the electric current, red colloidal gold solutions being simultaneously turned blue. I have investigated the behavior in this respect of completely reduced red solutions of colloidal gold, formed by the action of an ethereal solution of gold chloride dried at 170° on acetylene water containing ether.§ Such solutions contained in an ordinary beaker are apparently unaffected by the passage of the current for hours between gold or platinum wires 1^{mm} in diameter at a potential difference of 110 volts, unless, owing to the proximity of the electrodes, enough chlorine is liberated from the hydrochloric acid present to attack the colloidal gold with the formation of a solution of gold chloride from which ordinary gold is deposited on the cathode. This apparent inactivity toward the current is due to the fact that the conditions favor uniform diffusion of the gold throughout the liquid. When, on the other hand, the colloidal gold solution is contained in an ordinary U-tube, with an electrode in each arm, barely entering the liquid in order to avoid the diffusing effect of the escaping gases evolved by the current (amounting to about 0·005 ampère under the given conditions), electrical migration and concentration of the gold may be observed. Under these conditions, when contact is made, the gold immediately begins to settle from around the cathode with a clear surface of demarcation, leaving a colorless liquid, but never passing the bend of the U-tube; the gold solution around the anode grows deeper in color for about half an hour and then grows lighter in color, until after twelve hours or more only a faint pink tint remains, all the gold being now concentrated in a red cloud at the bend of the U-tube except for a slight deposit of dark-colored slime on the anode. When the U-tube was so constructed as to have a long horizontal portion between the two arms, the phenomena were unchanged, the red cloud forming midway between the

* Zsigmondy, Lieb. Ann., ccci, 29; Bredig, Anorganische Fermente, Leipsig, 1901, p. 28.

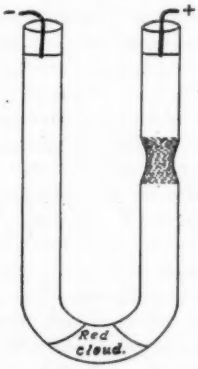
† Spring, Rec. trav. chim. Pays. Bas., xix, 215.

‡ Hardy, Jour. of Physiol., xxiv, 292.

§ Cf. this Journal, xvi, 381.

poles, thus showing that the effect is not due to gravity. The red cloud may at any time be readily diffused throughout the liquid by gentle agitation or warming, and slowly diffuses spontaneously when the current is broken. By withdrawing the clear liquid and dissolving the red cloud in pure water a purified red colloidal gold solution may be obtained.

This experiment becomes still more instructive if an asbestos plug be placed in one arm of the U-tube, just below the anode, as shown in the cut. If the plug is tight, the electrical osmosis of the liquid carries the gold with it to some extent. If the plug is loose, no movement of the liquid is observable and the gold moves in obedience to the current.



When the plug is loose the gold moves toward the anode as soon as contact is made, settling from around the cathode in exactly the same manner as in the former experiment; simultaneously a little gold is carried into the lower part of the asbestos plug below the anode, while that above the plug rises a little way, leaving the colorless liquid clearly defined. By the end of half an hour this latter surface of demarcation settles back to the asbestos plug, and thereafter for a long time (a week in one experiment, with interruption of the current over night) the gold solution above the plug remains unchanged, except that a dark-colored slime in slight amount forms on the anode, as in the former experiment. The gold below the asbestos plug not carried into it during the first half hour gathers in a red cloud at the bend of the U-tube as in the experiment where no plug was used. In the one experiment which was continued for a week, this red cloud practically all disappeared, and the gold which it contained was deposited in the lower end of the asbestos plug for a distance of 1^{cm}, coloring the asbestos red.

It was found that when the hydrochloric acid formed in the reduction of the gold chloride was removed from the colloidal gold solution by dialyzing the liquid until it became neutral to litmus, the electrical movements of the gold were not noticeably different from those given above. Also, when a red colloidal gold solution was prepared without the presence of ether, by the action of a dilute aqueous solution of gold chloride on acetylene water, the results were still the same.

These various occurrences may, perhaps, be explained as follows: All of the gold particles are originally negatively electrified and hence start toward the anode. This state of

affairs never changes in the arm of the U-tube carrying the cathode. But the gold particles at first concentrated around the anode by the action of the current give up their negative charge to that pole, and, being for some reason unable to remain in contact with it (except to a slight extent in the formation of the dark-colored slime), depart laden with a positive charge. Hence the surface of demarcation at first formed above the asbestos plug soon settles back to its original position, causing the plug to become positively charged, which then acts as the anode to the particles below it. The positively charged particles repelled from the lower end of the asbestos plug, or from the anode if no plug is present, meeting the negatively charged particles from the cathode, form some sort of a union, possibly by mutual attraction without disruption of the water envelopes with which they are surrounded, thus producing the red cloud at the bend of the U-tube. The fact that the gold in this cloud was ultimately carried into the asbestos plug in the one experiment continued for a week shows that the positively charged particles present in the cloud must slowly lose their charge; and both that fact and the fact that diffusion restores the original conditions* indicate that the union of positively and negatively charged particles in the red cloud is very feeble. The fact that the gold above the plug does not settle, on the other hand, is a further indication that some kind of aggregation of oppositely charged particles must take place to form the red cloud in the bend of the U-tube.

The formation of the red cloud midway between the electrodes in these experiments closely resembles the formation of a precipitate similarly situated observed by Lehmann† in his study of suspensions made viscous by gelatine. A dark-colored corona gradually extended from the anode and a light-colored corona from the cathode. Midway between the electrodes the coronas met with the formation of a precipitate and the liberation of heat. So, also, the reverse or "secondary movement" noticed by Hardy‡ in the case of egg-albumen, as well as the reverse movement of haemoglobin noticed by Gamgee,§ must be closely similar in their nature to the backward movement of the gold here described.

II. *Behavior toward Electrolytes.*

Bodländer‖ and Spring¶ have each insisted that in studying the action of electrolytes on permanent suspensions it is necessary to distinguish two phenomena: (1) Coagulation; (2) Pre-

* Cf. post, p. 441.
† Wied. Ann., lii, 455.
‡ Loc. cit.
§ Proc. Roy. Soc., lxx, 79.
‖ Neues Jahrb. f. Mineral., ii, 156.
¶ Loc. cit.

cipitation. A considerable amount of an electrolyte up to a definite limit can be added to a permanent suspension without causing any appreciable sedimentation within a reasonable length of time. This portion of the electrolyte is concerned in bringing about "coagulation." The further addition of an electrolyte after the above limit has been reached causes sedimentation to take place, the rate of settling varying with the amount of electrolyte thus added. This portion of the electrolyte is concerned in bringing about "precipitation." In working with colloidal gold solutions it is necessary to distinguish five effects:

(1) Coagulation of red gold solutions.
(2) Precipitation of red gold solutions.
(3) Coagulation of blue gold solutions.
(4) Precipitation of blue gold solutions.
(5) Transformation of red gold solutions into blue gold solutions.

Transformation of red colloidal gold solutions into blue colloidal gold solutions, with subsequent sedimentation.

The most obvious change brought about in red colloidal gold solutions by the addition of electrolytes is the change of color from red to blue, with subsequent subsidence of the gold. The change of color was investigated to some extent by Hardy,* who used a dilute red colloidal gold solution produced by the action of phosphorus in ether on an aqueous solution of gold chloride. The difference in the stability of his solution and the one used in these experiments, as indicated by the strengths of the various electrolytes necessary to produce the change of color, is so great that the results here recorded may be found none the less interesting. A red gold solution prepared according to the method already described and diluted to contain 0·0490 grams of gold per liter was titrated with electrolytes of known strength, the change of color from purple to violet which ensues soon after the original red color has changed to purple being taken as the end-point. The time required for titration varied from two to five minutes, but the time factor is not active until the end-point is nearly reached. Consequently only the last portions of the electrolyte were allowed to drop regularly from the burette. The gold solution changed from violet to pure blue in about two minutes after the titration was completed and the gold all settled out in four or five hours—the maximum rate† of subsidence in water noted in any experiment, including the work on absorption.‡ The results are given in the following table.

* Proc. Roy. Soc., lxvi, 110; Zeitsch. Phys. Chem., xxxiii, 385.
† Cf. Durham, Chem. News, xxxvii, 47.
‡ This Journal, xvi, 381.

TABLE I.

Vol. of gold solution cm^3.	Electrolyte.	Amt. of elect. cm^3.	Averages for 50^{cm^3}.	Final concentration of electrolyte in terms of normal strength.
50	$\frac{n}{10}-KAl(SO_4)_2.12H_2O$	0·4	0·4	·0008 of $\frac{1 \text{ gram mol.}}{3}$ per liter.
50		0·4		
50		2·1		
50	$\frac{n}{100}-KAl(SO_4)_2.12H_2O$	2·2	2·2	·0004 of $\frac{1 \text{ gram mol.}}{3}$ per liter.
50		2·2		
50		2 8		
50		3·3		
50	$\frac{n}{10}-BaCl_2$	3·2	3·11	·0058 of $\frac{1 \text{ gram mol.}}{2}$ per liter.
50		3·0		
100		6·5		
50		3·4		
50	$\frac{n}{10}-Ba(NO_3)_2$	3·7	3·45	·0064 of $\frac{1 \text{ gram mol.}}{2}$ per liter.
50		3·3		
100		6·8		
50	$n-NaCl$	7·7	7·6	·13 of 1 gram. mol. per liter.
100		15·0		
20	$\frac{n}{10}-NaCl$	100		·083* of 1 gram mol. per liter.

These results are in accord with Whetham's† hypothesis, that the activity of electrolytes toward colloidal solutions is an exponential function of the valency of the basic elements which they contain, the final concentration of sodium chloride necessary to induce the change of color from red to blue being 22·4 times that of barium chloride, which, in turn, is 14·5 that of potassium alum. No amount of a tenth-normal solution of sodium chloride brings about the change of color within a reasonable length of time (see the last experiment of the table), the final concentration required, ·13-normal, being greater than that of a tenth-normal solution. The fact that the change of color takes place suddenly at a given concentration of the electrolytes and that a weaker concentration of the same electrolytes does not produce the change of color even after a considerable lapse of time, tends to disprove the hypothesis of Whetham, since time should be an active factor in bringing

* Solution not turned blue in two days.

† Jour. of Physiol., xxiv, 288; Phil. Mag., xlviii, 474.

about the change of color if it is the haphazard coincidences of gold particles and basic ions which condition the transformation, rather than some uniform and sudden change throughout the entire liquid, such as would be indicated by the observations of Bodländer on the coagulation and precipitation of kaolin suspensions.

That the effect of mixing two electrolytes whose basic elements have different valencies is subtractive rather than additive was shown by Linder and Picton* for colloidal solutions of arsenious sulphide and by Hardy† for colloidal solutions of egg-albumen, and is indicated by the following experiments, in which a red colloidal gold solution containing a known amount of a salt of a univalent basic radical was titrated to the violet color by barium chloride.

TABLE II.

Vol. of gold solution.	Electrolyte No. 1.	Amt. of el. No. 1.	Final conc. of el. No. 1.	Elec. No. 2.	Amt. of el. No. 2.	Final conc. of el. No. 2.
cm^3.		cm^3.			cm^3.	
50	$\frac{n}{10}-NH_4NO_3$	65	·052	$\frac{n}{10}-BaCl_2$	9·2	·0074
100	$\frac{n}{10}-NaCl$	100	·047	$\frac{n}{10}-BaCl_2$	14·5	·0068
50	[Average from Table I.]			$\frac{n}{10}-BaCl_2$	3·11	·0058

It seems impossible to reconcile these results with Whetham's hypothesis. It is evident that a quantitative study of the effects of mixtures of electrolytic substances in various proportions in turning red solutions blue offers an interesting field for the investigation of the properties of electrolytes themselves.

It was thought likely that the remarkable stability of these red colloidal gold solutions was due to the ether present, acting as a non-electrolyte in inhibiting the action of electrolytes after the fashion of typical colloids, such as gelatine—a phenomenon first pointed out by Faraday,‡ and applied by Lottermoser and Meyer,§ Zsigmondy‖ and others. Consequently the following experiments were made on the same gold solution used above, but diluted with four volumes of water. To this diluted solution various amounts of ether were added before titration. The results are given in the following table.

* Jour. Chem. Soc., lxvii, 63. †Jour. of Physiol., xxiv, 182.
‡ Phil. Trans., cxlvii, 145. §Jour. Prakt. Chem., lvi. 248.
‖ Zeitsch. Anal. Chem., xl, 697; Schulz and Zsigmondy, Hofmeister's Beiträge, iii, 137.

TABLE III.

Volume of gold solution, 50^{cm^3}.

Volume ratio of ether added.	$\frac{n}{100}$—KaAl—$(SO_4)_2.12H_2O$ cm^3.	Averages. cm^3.	Final concentration of electrolyte in terms of normal strength.
	1·8		
	1·7	1·8	·00035
	1·9		
	1·9		
	2·58		
	2·65		
1 : 50	2·50	2·61	·00050
	2·70		
	3·15		
1 : 25	3·05	3·18	·00060
	3·35		
Saturated, exposed to air during titration.	5·00	5·00	·00091
Saturated, titrated under ether.	8·75	8·98	·00151
	9·20		

of $\frac{1 \text{ gram mol.}}{3}$ per liter

In the last two experiments of the table neither aluminium nor sulphuric or hydrochloric acid could be found in the ether. Hence it appears that the presence of the ether tends to inhibit the action of electrolytes to such an extent that a red gold solution kept saturated with ether by a superimposed layer of it required more than four times as great a concentration of the potassium alum to produce the change of color as was required by a solution containing the same amount of gold and acetylene and but very little ether. The effect, if any, of varying the amounts of gold and acetylene is covered up by the simultaneous variations produced by changes in the amount of ether present.

Since it was found impossible to turn red colloidal gold solutions blue in the experiments with the electric current detained at the beginning of this paper, other electrical means of bringing about the change of color were sought; but neither the alternating current from an induction coil, giving an inch spark in air, nor long-continued sparking between gold electrodes with the direct current, as in Bredig's* method of pre-

* Loc. cit. Zeit. angew. Chem., 1898, p. 951; Bredig and Reinders, Zeit. Phys. Chem., xxxvii, 323.

paring gold hydrosols (aqueous colloidal solutions), served to bring about the desired result.† Hence the following experiments were made in order to find out, if possible, whether electrical phenomena were demonstrably concerned in bringing about the change of color. In the experiments given under A of Table IV a red colloidal gold solution containing 0·0193 gram of gold per liter was titrated with electrolytes without the presence of the current, for purposes of comparison; in those given under B the titration was made in the presence of electrodes of platinum wire at a potential difference of 110 volts and 0·5^{cm} apart. In these experiments the first noticeable change of color of the liquid from red to purple was taken as the end-point. Under these conditions the liquids included under A, as well as those titrated with sodium sulphate under B, assumed a distinct purple or violet color within ten minutes after the titration was completed, but the gold remained suspended for some days, finally settling in the form of a purple or violet powder. The liquids titrate with potassium alum in the presence of the current changed from purple to blue almost at once.

TABLE IV.

Volume of gold solution, 100$^{cm^3}$.

A. Titrated without the electric current.

Electrolyte.	Amt. of elect. cm^3.	Averages.	Final concentration of electrolyte in terms of normal strength.
$\frac{n}{100}-KAl(SO_4)_2.12H_2O$	3·19 2·90 2·95	3·01	·00029 of $\frac{1 \text{ gram mol.}}{3}$ per liter
$n-Na_2SO_4$	15·8 16·4 17·2	16·3	·140 of 1 gram mol. per liter
B. Titrated in the presence of the electric current.			
$\frac{n}{100}-KAl(SO_4)_2.12H_2O$	1·36 1·45 1·25	1·35	·00013 of $\frac{1 \text{ gram mol.}}{3}$ per liter
$n-Na_2SO_4$	20·4 18·2 21·8	20·1	·167 of 1 gram mol. per liter

These results are sufficient to show that the phenomena involved in the titration of red gold solutions with electrolytes in the presence of the electric current are complex and demand

* Cf. Spring, loc. cit.

extended investigation. Thus the presence of the electric current increased the activity of the potassium alum, but retarded that of the sodium sulphate. Since the acid radicals were the same, it is necessary to attribute the difference in behavior to the basic radicals, thus strengthening the belief that the basic radical is the active factor in causing precipitation when the current is not acting. In one experiment with a hundredth-normal solution of potassium alum, it was found that the amount of electrolyte required to turn the red solution blue was not changed by the passage of the current under the same conditions as before for ten minutes and subsequent titration after the current was broken. This supports the conclusion arrived at above (p. 435) that red colloidal gold solutions are not necessarily permanently affected by the passage of the electric current.

The separate coagulation and precipitation of red gold solutions and the separate coagulation and precipitation of blue gold solutions, as well as the reverse change of color from blue to red with its apparent hysteresis, are being studied further. The fact that these gold solutions show five different effects on the addition of electrolytes, instead of two as in most colloidal solutions, renders them exceedingly interesting from a theoretical standpoint. Until the activity of electrolytes in bringing about each of these effects is better understood and differentiated, it would seem that speculation with regard to the causes which induce them would be idle; for in the process of turning red solutions blue as ordinarily conducted all five phenomena are doubtless involved. Some results obtained by titrating the same gold solution first to the purple color, then immediately to the violet color, are given below. The fact (noted above) that in the former case the gold settles slowly in the form of a purple or violet powder, in the latter case in the form of a blue powder and at the maximum rate, indicates that within the limits between the two readings is included the entire range of concentration of the electrolyte necessary to increase to the maximum the rate of subsidence of the red gold, to complete the change of color from red to blue, and to precipitate the blue gold thus formed.

TABLE V.

Volume of gold solution, 50^{cm^3}. Electrolyte, $\frac{n}{100}KAl(SO_4)_2.12H_2O$.

Titrated to purple.		Titrated to violet.	
2·25		3·65	
2·45		3·40	
2·50		3·45	
2·40	2·41	3·45	3·49
2·70		3·55	
2·30		3·50	
2·30		3·40	

ART. XLIII.—*Is the Peak of Fernando de Noronha a volcanic plug like that of Mont Pelé?* by JOHN C. BRANNER.

IT is doubtful whether the writer would have ventured the suggestion made by the title of this note if the idea had not occurred many years ago to no less a person than Charles Darwin. In his "Journal," new edition, New York, 1878, p. 11, Mr. Darwin says of the island of Fernando de Noronha: "The most remarkable feature is a conical hill about one thousand feet high, the upper part of which is exceedingly steep, and on one side overhangs its base. The rock is phonolite, and is divided into irregular columns. On viewing one of these isolated masses at first *one is inclined to believe that it has been suddenly pushed up in a semi-fluid state.* At St. Helena, however, I ascertained that some pinnacles, of a nearly similar figure and construction, had been formed by the injection of melted rock into yielding strata, which thus had formed the moulds for these gigantic obelisks."

The italics (not Mr. Darwin's) direct attention to the chief point of interest in the present connection. In his "Geological Observations," second edition, page 27, Darwin again refers to the Fernando peak, as follows: "At St. Helena there are similar great, conical, protuberant masses of phonolite, nearly 1,000 feet in height, which have been formed by the injection of fluid feldspathic lava into yielding strata. If this hill has had, as is probable, a similar origin, denudation has been here effected on an enormous scale."

The writer spent some months on the island of Fernando many years ago while a member of the Geological Survey of Brazil, and an article on its geology was published in this Journal in February, 1889. The following is quoted from that paper (vol. cxxxvii, page 152): "The Peak is the most striking landmark in the South Atlantic Ocean; it is 1000 feet high, with the upper portion perpendicular or overhanging in such a manner as to make the summit quite inaccessible. The few drawings of this peak that have been published are taken from the same point—the anchorage—and even the best of them, that in the Challenger reports, conveys but a poor idea of its grandeur. Seen from other points it presents a striking variety of outlines." Two cuts of the peak are given in that article, one of which was reproduced by Professor Dana in his Manual of Geology, 4th ed., p. 263. Owing to the points of view, neither of these cuts, however, gives a just idea of the shape of the peak. The one in Dana's Geology was made from a photograph taken with the camera pointing up at an angle of forty-five degrees.

1

The Peak of Fernando de Noronha seen from the land to the south. From a photograph made by J. C. Branner in July, 1876.

With this note is given a drawing (fig. 1) made from a photograph taken by the writer in 1876 from the plateau above which the peak rises; the observer looks northwest, and the peak is about a mile away. Attention is called to the upper slope on the right, and to its general resemblance to fig. 5, plate XII, of Dr. Hovey's description of the new cone of Mont Pelé published opposite page 276 of this Journal for October, 1903.

Fig. 2 is a sketch made by the writer from a point a little farther to the north and from a distance of about three-quarters of a mile. This view shows both the peak proper and the hill at its base on the west, which is of the same kind of rock as the peak itself, that is, phonolite. On the right the talus slope descends to the sea beach. The attention is called to the resemblance of this view to the profile given in fig. 3 of

Dr. Hovey's paper on Mont Pelé. The drawings are on different scales.

The vertical part of the rock is about 500 feet high. The edge of the plateau from which the sketch was made is shown in the foreground of fig. 2; it is about 275 feet above the ocean (aneroid) and this may be taken as nearly the general level of the island.

2

The Peak of Fernando de Noronha seen from the plateau above the village. A sketch made in July, 1876.

But little importance was attached to Mr. Darwin's suggestion in regard to the origin of the peak of Fernando until recent developments on Martinique brought it again to mind. It certainly is true that upon any other theory than that of the formation of the peak as a volcanic plug we have an amount of erosion to account for that does not seem to be in harmony with the general topography of the island.

But while the resemblance of the peak to the Mont Pelé plug is striking, it is realized that this resemblance may be quite accidental.

In Nature for October 15, 1903, p. 573, Sir Richard Strachey calls attention to a case in India of which the Mont Pelé peak reminds him.

Art. XLIV.—*Studies in the Cyperaceæ;* by Theo. Holm.
XX. "*Greges Caricum.*"*

Of the two methods adopted for the classification of species, and especially of those pertaining to large genera, the artificial system, of course, has the advantage of being the most convenient, but seldom leads further than to their immediate determination. The natural classification is, on the other hand, much more difficult by being based upon supposed affinities between the species themselves, thus excluding such morphological characters as are common to a number of species, but of no importance from a biological point of view. Let us, for instance, consider Linnæus' classification of the species of *Carex*. When he treated the genus, "Vignea" had not yet been invented, and the "Indicæ" were not known. And with the object in view to render the determination of the species as easy as possible, Linnæus arranged these in accordance with the inflorescence, this being a single spike: staminate, pistillate or androgynous, or the spikes being several: androgynous or with the sexes separate, the pistillate spikes being either sessile or peduncled. Such classification is, of course, very artificial, considering the fact that the monostachyous species contain representatives of very different habit and of very different structure of the perigynium. But it is much less artificial than the system in which the species are simply classified as *Vigneæ:* all those with two stigmata, and *Carices genuinæ:* those with three. For in the former, the *Vigneæ*, if the number of stigmata be the most important character, the species must necessarily become badly mixed, since then *Carex vulgaris, leniticularis, angustata* and their numerous allies must be arranged side by side with *C. rosea, muricata, stellulata, vulpinoidea, stipata*, etc. The Linnæan method is still adopted in a number of manuals and systematic works, where it figures prominently in the artificial keys, and justifiably so. But it is rather surprising that the author, who treated the *Cyperaceæ* in the very modern and comprehensive work: "Die natürlichen Pflanzenfamilien," should not have felt called upon to give a more natural classification of the *Carices* than the one adopted, where

* Earlier numbers were published in this Journal as follows: No. 1 in vol. i, Fourth Series: 348, 1896—No. 2 in vol. ii: 214, 1896—No. 3 in vol. iii: 121, 1897—No. 4 in vol. iii: 429, 1897—No. 5 in vol. iv: 13, 1897—No. 6 in vol. iv: 298, 1897—No. 7 in vol. v: 47, 1898—No. 8 in vol. vii: 5, 1899—No. 9 in vol. vii: 171, 1899—No. 10 in vol. vii: 435, 1899—No. 11 in vol. viii: 105, 1899—No. 12 in vol. ix: 355, 1900—No. 13 in vol. x: 33, 1900—No. 14 in vol. x: 266, 1900—No. 15 in vol. xi: 205, 1901—No. 16 in vol. xiv: 57, 1902—No. 17 in vol. xiv: 417, 1902—No. 18 in vol. xv: 145, 1903—No. 19 in vol. xvi: 17, 1903.

the species appear in the old-fashioned sections: *Mono-*, *Homo-* and *Hetro-stachyæ* with the same distinction in regard to the distribution of the sexes as once proposed by Linnæus, and regardless of "natural affinities." We are told that *C. pauciflora* and *rupestris* together constitute one division "*Rupestres*," because they are monœcious and tristigmatic, while *C. cephalophora* and *Baldensis* represent the "*Bracteosæ*," because their inflorescence is capitate and subtended by leafy bracts, even if the former be distigmatic, the latter tristigmatic; moreover that *C. macrocephala* and *curvula* constitute the "*Curvulæ*" because both have three stigmata and a spicate-capitate inflorescence.

Almost a century after Linnæus had described the *Carices*, the genus became divided by Beauvais* in "*Vignea*" with two stigmata and a plano-convex achænium and "*Carex*" with three stigmata and a trigonous achænium. As a subgenus or at least as a section "*Vignea*" has been preserved, but not as a genus. A third section became proposed by Tuckerman,† the so-called "*Vigneastra*" including the *Indicæ*, and these were characterized as possessing androgynous, ramified spikes and two or three stigmata. This paper by Tuckerman actually contains the first attempt in combining the *Carices* in natural groups with names indicating the most characteristic type of each. Tuckerman did, however, begin his new system with the *Psyllophoræ*, the monostachyous, and passed from these over the *Vigneæ* and *Vigneastra* to the *Legitimæ*, somewhat similar to the old method. And he omitted to write the diagnoses of his groups, leaving the reader to interpret the affinities. But in the appended "Annotationes" Tuckerman expressed his views regarding the affinities of a few types, and he suggested, for instance, that the *Psyllophoræ* might perhaps be referable to the *Vigneæ* and *Legitimæ*, that the *Dioicæ* might belong to the *Stellulatæ*, the *Scirpinæ* to the *Montanæ*, and the *Rupestres* to the *Digitatæ;* in other words, Tuckerman had evidently grasped the correct idea of eliminating the *Monostachyæ* altogether as a section and to classify them as lesser developed types of the *Stellulatæ*, etc.

This same idea we find expressed, but much more carefully worked out in the posthumous work "Symbolæ Caricologicæ," published by Vahl under the auspices of the R. Danish Academy (1844). The author, Salomon Drejer, with remarkable skill undertook to treat the genus from a phyletic point of view, and he defined the transition from the lesser developed types to the more advanced in such a way as to overthrow the older, artificial classification. The number of stigmata, the

* In Lestiboudois' Essai sur la famille des Cypéracées, Paris, 1819, p. 22.
† Enumeratio methodica, 1843, p. 10.

distribution of the sexes and the form of the inflorescence had with him no weight unless they were in correlation with other characters which might be considered of biological importance, such as the structure of the perigynium (*utriculus*). In this way the species of the old section *Monostachyæ* became transferred to various pliostachyous groups as representing "formæ hebetatæ" of these, and even the *Indicæ* with their manifold decompound inflorescences, even these he did not feel inclined to preserve as distinct from the others. Only the *Vigneæ* and *Carices genuinæ* were recognized, though with the understanding that the former should not be restricted to distigmatic species alone, nor the latter to tristigmatic species.

Characteristic of the *Vigneæ* is, thus, not only the more or less dense-flowered, spicate or capitate inflorescence with commonly both sexes represented in each of the smaller spikes, or the normally two stigmata, but also the peculiar structure of the perigynium, being mostly plano-convex with the margins more or less prominent and the beak being usually slit deeper on the convex face, a structure that is, however, also met with in certain species of the *Carices genuinæ*, for instance among the *Stenocarpæ*. In the *Carices genuinæ* the perigynium exhibits three types, one in which the beak is very short, entire or subemarginate, a second in which there is a distinct beak with the orifice hyaline, two-lobed or irregularly bifid, while in the third type the beak is quite prominent with the apex bifid or even bidentate.

These three types of perigynium were suggested by Drejer as being sufficiently valid for dividing all the genuine *Carices* in three primary sections, as already indicated in his little book: Revisio critica Caricum borealium.—But this general classification does not, however, seem feasible when we remember the several modifications that are noticeable among the lesser and higher developed types within the minor "greges." On the other hand, we must fully admit the recognition of these characters as being very important, when applied to the central, specific types of each "grex," and when taken in connection with the other characters, which Drejer suggested as fundamental for the establishment of his "greges." He enumerates, for instance, the consistence of the perigynium, membranaceous or spongious, its surface being glabrous or pubescent, the bracts being leafy or scale-like, sheathing or merely auriculate at base, the spikes being erect or drooping, contiguous or remote, and finally the distribution of the sexes; this last character he considered, however, to be of minor importance, since it appears inconstant in a number of cases.—With these characters in mind Drejer classified a number of *Carices genuinæ* in eleven "greges" with diagnoses appended, but as already

stated, his manuscript was left unfinished by his premature death, and none of the *Vigneæ* had been treated, nor did he leave any notes upon these. However, the general idea which he had formed relating to the classification of the latter is so clearly expressed in the introduction of his paper, that the "*greges*" of these, the *Vigneæ*, may be well constructed on the same basis as the others. But the method proposed by Drejer for the classification of these numerous species is so original and so distinct from any of the previous methods, for instance those suggested by Kunth, Fries and others, thus no comparison or combination of these seems possible.—If the *Vigneæ* be treated and if some new "greges" be suggested as supplemental to the *Carices genuinæ*, the treatment must be carried out in accordance with the same principles as once suggested by Drejer, whenever we intend to adopt and follow his method.

Nevertheless, an attempt has been made* to classify the *Vigneæ* and the *Carices genuinæ* in natural sections: the former in accordance with Fries, viz., *Acro-* and *Hyparrhenæ*, i. e. in accordance with the distribution of the sexes: with the staminate flowers borne at the top of the spikes or at the base of these, and the latter, the *Carices genuinæ*, in accordance with Drejer. It is readily perceived that these two methods are not to be combined, since the former, the one of Fries, is founded upon merely artificial characters, while the latter strives to be as natural as possible. Moreover, the interpretation of the "greges," proposed by Drejer, is far from correct, in spite of the fact that the diagnoses have been written in excellent Latin. Let us, for instance, examine the *Trachychlænæ* Drej., as interpreted by Professor Bailey. With Drejer this "grex" contained such species as *C. glauca*, *hispida* and *trinervis*, while Professor Bailey has made it a complex of utterly different types and with the exclusion of *C. glauca*, which this author, strange to say, has referred to the *Acutæ* of Fries. This section, the *Acutæ*, did not, however, with Fries contain such species as *C. glauca*, but only *C. acuta* and *prolixa*, while Fries himself had *C. glauca* as a member of "*Pallescentes*." And the treatment of the *Vigneæ* by combining the various and very incongruous sections of Kunth, Fries, Nyman, Christ and Tuckerman has necessarily resulted in confusion.

A somewhat more successful attempt has been made by Rev. G. Kükenthal in his treatment of some South American *Carices*, in which the *Acro-* and *Hyparrhenæ* have become dissolved into groups that are more natural, and where the

* Bailey, L. H. Proceed. American Acad. Arts and Sci., vol. xxii, p. 59, 1886.

various sections or greges have been more correctly interpreted. However, the combination of *Microrhynchæ* and *Æorastachyæ* does not seem natural to us, and we can not either accept the *Bifurcatæ* Kükthl. as an alliance of two groups as distinct as the *Physocarpæ* and *Echinostachyæ*, nor can we accept the *Leptocephalæ* and *Physocephalæ* Bail. And the *Dactylostachyæ* Drej. were hardly intended for such divergent types as the *Oligocarpæ* or the *Laxifloræ*, nor does it seem natural to refer *Phyllostachys* as a whole or in part to the *Sphæridiophoræ* Drej. Whether the *Vigneastra* be distinct from the *Vigneæ* and *Carices genuinæ* remains to be seen; the characterization of the *Graciles*, the *Polystachyæ* and *Indicæ* at least does not seem to warrant any such segregation. If the author had treated a larger number of species and from other parts of the world, he would no doubt have altered some of his views and enlarged the number of "greges," especially of the *Vigneæ*.

Similar to the system adopted by Professor Bailey, Mr. Kükenthal has made a number of combinations of groups formerly proposed by Kunth, Fries, Tuckerman and others. And as we have stated above, such combinations are not always feasible, when we bear in mind that the principles upon which these classifications were based are quite distinct. We might illustrate this by an example taken from the *Canescentes* of Fries, as accepted by Mr. Kükenthal and Professor Bailey.

Fries himself defined the *Canescentes* as "Hyparrhenæ *β canescentes:* typice albidæ" including such species as *C. canescens*, *remota*, *stellulata*, *tenuiflora* and a few others. With Mr. Kükenthal the *Canescentes* are species with: "utriculi neque alati neque marginati neque spongiosi brevirostres vel erostrati," and excluding *C. remota*, which is transferred to another section: the *Remotæ* of Ascherson.

With Professor Bailey the *Canescentes* Fr. is supposed to be identical with the *Elongatæ* Kunth, the *Tenuifloræ* Kunth, the *Heleonasteæ* Kunth, the *Stellulatæ* Kunth, the *Deweyanæ* Tuckm., the *Loliaceæ* Nym., the *Monastes* Nym. and *Lagopinæ* Nym.

It would seem from the above statements that an independent treatment would be safer, since such contradictions as are liable to arise from combined systems would be averted. And with the object in view of establishing a classification of *Vigneæ* and *Carices genuinæ* in accordance with the principles suggested by Drejer, the writer has made an attempt to arrange a number of species from various parts of the world, but mostly from the northern hemisphere, and only such as have been directly accessible to study and represented by sufficient material. The result of our study is, as will be seen from the following pages, the maintenance of the *Vigneæ* and *Carices genuinæ*, while

the *Vigneastra* appear to us as inseparable from these, especially from the latter. That we enumerate the *Vigneæ* before the *Carices genuinæ* must not be understood as if it were our idea that these are older than the others; we consider them both as two parallel groups that evidently developed from certain monostachyous types, branching out in several, more or less restricted "greges." In these, the "greges," we have begun with the simplest types, when such are represented in the shape of monostachyous species: "*formæ hebetatæ.*" The supposed central types are so indicated, but besides these there are usually certain species which cannot be placed in direct sequence with these, and which to some extent show transition to other "greges;" these are enumerated as "*Desciscentes.*"

As to the arrangement of the "greges" we have begun with those which we suppose are the least advanced in each group; among the "greges" themselves are several which to us appear as illustrating a parallel development, for instance *Athrochlænæ-Stenocarpæ* and *Podogynæ*, *Trichocarpæ-Echinochlænæ*, etc. When we compare the "greges" of the *Vigneæ* with those of the *Carices genuinæ* it is readily seen that there are several types among the latter which habitually remind us of the former, the *Vigneæ;* such analogies are not uncommon among the *Melananthæ*, the *Athrochlænæ* and the *Chionanthæ.*

However these analogies do not extend beyond the mere composition of the inflorescence and especially in regard to the distribution of the sexes: the spikes being often androgynous or gynæcandrous as in the *Vigneæ.* While apparently typical to several species, androgynous or gynæcandrous spikes occur so frequently among the *Carices genuinæ*, the formerly so-called "*Heterostachyæ*," that this character seems too fallacious to be depended upon to any large extent. But some exceptions exist, and we have not, so far, observed a single case where the terminal spike was not gynæcandrous in such species as *C. triceps*, *virescens* and *Shortiana*, to which such structure seems to be typical, besides a number of others, i. e. *C. squarrosa*, *atrata*, *alpina*, *Buxbaumii*, etc., even if exceptions be not infrequent.

It seems, also, to be a marked characteristic of the so-called "*Vigneastra*" that most of the spikes or sometimes all of them are androgynous, but as we have already stated, we have not felt induced to maintain this section, since none of the species, which we have had an opportunity of examining, proved distinct from the *Carices genuinæ.* While some of these *Vigneastra* possess a habit that is very distinct from other *Carices*, it is not difficult to see several and very important analogies in their morphological structure by which the distinction becomes very faint and hardly sufficient for the

segregation of these as a special group. The following points may be taken into consideration: Tuckerman, who established the group, mentions the decompound spikes as being branched and androgynous, and the number of stigmata varying from two to three, and of the four sections enumerated by him, the writer has examined representatives of the *Indicæ*, the *Polystachyæ* and the *Graciles*, all of which have been accepted by Mr. Kükenthal (l. c.).

Of these the *Graciles* should include distigmatic species with mostly simple and single spikes; the *Polystachyæ*, on the other hand, should possess numerous spikes, from two to four together from each sheath, and with two or three stigmata, while in the *Indicæ* the spikes constitute a widely ramified inflorescence of which the secondary and tertiary axes are developed from perigynium-like organs, and the stigmata being constantly three. Among the *Graciles*, *C. brunnea* Thunbg. is a good type, and it is true that all the spikes are androgynous, and that the spikes are very often only one or two together on the same peduncle, and that the stigmata are but two. Nevertheless, this species can by no means be segregated from the *Carices genuinæ* on that account, but is barely referable to any of the *Vigneæ*, since the spikes are cylindrical, borne on long and slender peduncles, besides that the structure of the perigynium is very different from that of any member of the *Vigneæ*, being ellipsoid, much flattened, prominently striate, hairy on the nerves, and abruptly narrowed into a linear, bifid beak. It happens, however, that the perigynium is sometimes glabrous in Non-Indian examples, as stated by Mr. Clarke, but even such specimens would hardly be referable to the *Vigneæ* either.

Of the second section, the *Polystachyæ*, *C. Jamesonii* Boott shows us a plant with very long and slender, cylindrical, androgynous spikes, borne on long peduncles and more or less branched from the base. These branches are subtended by narrow bracts, somewhat longer than the scales but otherwise not different from these, and they all proceed from an ochrea-like perigynium, but of which the flower is not developed; each secondary branch is thus merely the rhacheola extended, as is very frequently observed in a number of *Carices genuinæ*, even if it may be somewhat abnormal in these. Furthermore, in *C. Jamesonii* there are several peduncles developed from each leaf-sheath, making the inflorescence ample and rich-flowered, but otherwise the principal structure is well comparable with that of the inflorescence of the *Carices genuinæ;* we suggest the affinity of this species to be with the *Hymenochlænæ*.

Much more singular in structure and habit are the *Indicæ*, of which we might consider *C. cladostachya* Wahl. The

culms are branched in almost their whole length and from the numerous leaf-sheaths long peduncled, androgynous spikes proceed, of which the secondary ramifications are sessile and developed from perigynia without flowers. These empty perigynia correspond, as we have described before,* with the basal ochreæ, but differ from these by their function and structure. Their function is to spread the lateral spikes into an horizontal position, and this takes place by means of a swelling of the base of these small organs. In other words, they represent prophylla with purely mechanical function, as we remember so well from the similar, but much higher developed, sheath-like prophylla in the umbels of *Cyperus*. The minor inflorescences of *C. cladostachya* may look more like those of a *Vignea*, but the presence of the empty perigynia with their special function makes the species better comparable with some of the *Carices genuinæ*, in which similar rudimentary and basal perigynia have been observed. The *Indicæ* contain, thus, the most singular types of the *Vigneastra*, but we have, nevertheless, failed to find a single point in their combined morphological structure by which their segregation from the others might be warranted. The almost constant presence of both sexes in each spike is of course noteworthy, but such androgynous inflorescences are, as we know, not uncommon among the other *Carices*. And we think that such cases where a species with normally gynæcandrous spikes appears as inseparable from others which are truly heterostachyous, that such cases may be considered more anomalous than when we place the *Vigneastra* as members of the various "greges" of *Carices genuinæ*.

We refer to *C. Magellanica*, of which the lateral spikes are normally gynæcandrous; still no one would doubt its affinity to be with *C. limosa* and *rariflora*. And we might, also, recall the singular *C. stenolepis* in which the lateral spikes are constantly gynæcandrous besides, not infrequently, the terminal, and the affinity of this species seems, notwithstanding, to be with the *Spirostachyæ*, as suggested by Drejer (l. c.).

Some few "*Carices genuinæ*," for no author has as yet segregated them from these, deserve just as much the distinction of being enumerated as *Vigneastra* as those mentioned by Tuckerman, Bailey and Kükenthal, and these are: the pliostachyous *C. Willdenovii*, *Steudelii*, *Backii*, *illegitima*, *Linkii* and *pedunculata* with all the spikes androgynous and in no wise to be distinguished from the *Vigneastra*;† the only difference which we see lies in their smaller size. There is, on the other hand, a species which we have enumerated as a member of the *Carices genuinæ*, and which, according to our opin-

* This Journal, vol. ii, 1896, 214, and vol. x, 1900, p. 33.
† This Journal, vol. x, 1900, p. 33.

ion, represents the most peculiar type among these; this is *C. Fraseri*. By the structure of its leaf, being destitute of sheath, ligule and midrib in connection with the characteristic inflorescence and rhizome,* this species would be better separable from the other *Carices* than any of the most highly developed *Vigneastra*.

Synopsis of the "greges."

I. VIGNEÆ.

Brachystachyæ nob.

Spikes several, short, few-flowered, sessile, remote or the upper ones contiguous, gynæcandrous or, but seldom, androgynous; the bracts often conspicuous, but very narrow; scales mostly hyaline; perigynia somewhat spreading, green or light brown, ovate, mostly sessile, plano-convex, nervose, glabrous or a little scabrous along the upper margins, sometimes spongious at the base, the beak short, obliquely cut or almost entire; stigmata two.

Centrales: *C. trisperma* Dew., *tenuiflora* Wahl., *loliacea* Schk., *macilenta* Fr., *canescens* L., *vitilis* Fr., *helvola* Bl., *Bonanzaensis* Britt.

Desciscentes: *C. microstachya* Ehrh., *tenella* Schk.

Neurochlænæ nob.

Spikes several, short but many-flowered, sessile, mostly contiguous, gynæcandrous or the lateral wholly pistillate; bracts inconspicuous; scales brownish; perigynia erect, brownish or dark green, often shortly stipitate, elliptical to oval or roundish, plano-convex, nervose, glabrous or scabrous above, the beak very prominent, at least in the central types, slit on the convex face, the orifice hyaline; stigmata two.

Hebetatæ: *C. nardina* Fr., *oreophila* Mey., *ursina* Dew.

Centrales: *C. glareosa* Wahl., *lagopina* Wahl., *Pribylovensis* Macoun, *cryptantha* Holm, *neurochlæna* sp. n.,† *heleonastes* Ehrh., *norvegica* Willd.

Argyranthæ nob.

Spikes several, mostly short and loose-flowered, sessile, contiguous or the lower ones remote, gynæcandrous or the lateral wholly pistillate; bracts short and narrow; scales hyaline or light brown; perigynia erect, membranaceous, light green, stipitate, lanceolate, plano-convex, nervose, serrulate along the narrow margins, the beak long, bidentate; stigmata two.

Centrales: *C. Deweyana* Schw., *bromoides* Schk.

* This Journal, vol. iii, 1897, p. 121.

† The diagnoses of the new species will be published in a subsequent paper in this Journal.

Astrostachyæ nob.

Spikes several, short and few-flowered, sessile, remote, gynæcandrous or the lower ones purely pistillate; bracts short and narrow; scales brownish; perigynia spreading, brownish, sessile, cordate or ovate, plano-convex, nervose, spongious at the base, winged, tapering into a serrulate, bidentate beak; stigmata two.

Hebetatæ: C. dioica L., *paralela* Læst., *gynocrates* Wormskj., *Davalliana* Sm., *exilis* Dew.
Centrales: C. stellulata Good., *scirpoides* Schk., *sterilis* Willd., *interior* Bail., *albata* Boott, *nubigena* Don, *elongata* L., *læviculmis* Meinsh.
Desciscens: C. remota L.

Acanthophoræ nob.

Spikes several, mostly short, but often dense-flowered, sessile, contiguous or remote, androgynous; bracts often long, but narrow; scales brownish; perigynia somewhat spreading, brownish, mostly sessile, ovate and acuminate to suborbicular and abruptly beaked, plano-convex, faintly nerved or nerveless, spongious at the base, narrowly winged, the beak serrulate, bidentate; stigmata two.

Centrales: C. rosea Schk., *divulsa* Good., *sparganioides* Muehl., *Muehlenbergii* Schk., *glomerata* Thunbg., *cephaloidea* Dew., *muricata* L., *lejorhyncha* Mey., *Hookeriana* Dew., *occidentalis* Bail., *vagans* sp. n., *trachycarpa* Cheesem., *Hoodii* Boott, *gravida* Bail., *alopecoidea* Tuckm., *conjuncta* Boott., *vulpina* L., *phaeolepis* sp. n., *chrysoleuca* sp. n., *vitrea* sp. n.
Desciscentes: C. cephalophora Muehl., *vulpinoidea* Michx., *vicaria* Bail., *Maackii* Maxim., *gibba* Wahl.

Stenorhynchæ nob.

Spikes several in a dense-flowered, decompound panicle or head, sessile, contiguous, androgynous; bracts conspicuous, but usually narrow; scales green or light brown; perigynia spreading, light brown or greenish, stipitate, ovate, tapering into a very long, bidentate beak, plano-convex, nervose, the narrow margins serrulate; stigmata two.

Centrales: C. crus corvi Shuttlew., *stipata* Muehl.

Sychnocephalæ nob.

Spikes numerous in a dense-flowered head, sessile, gynæcandrous; bracts very long, leaf-like; scales green or light brown; perigynia erect, linear-lanceolate, acuminate, light green, stipitate, compressed, few-nerved, wingless, the beak very long, serrulate, bidentate; stigmata two.

Centrales: C. cyperoides L., sychnocephala Carey.

Xerochlænæ nob.

Spikes many, rather large, in a dense-flowered, spicate inflorescence, sessile, mostly contiguous, androgynous; bracts often conspicuous, setiform; scales brownish; perigynia mostly erect, seldom spreading, brown, stipitate or sessile, broadly ovate to orbicular, plano-convex, nervose, more or less winged, serrulate, tapering into a distinct, bidentate beak; stigmata two, seldom three. Some species show tendency of becoming dicœcious.

Centrales: C. divisa Huds., *marcida* Boott, *Sartwelli* Dew., *disticha* Huds., *repens* Bell., *arenaria* L., *arenicola* Fr. et Sav., *Kirkii* Petrie, *potosina* Hemsl, *Schreberi* Schr., *brizoides* L.
Desciscentes: C. inversa R. Br., *resectans* Cheesem., *Douglasii* Boott, *macrocephala* Willd.

Psyllophoræ Lois. ex p.

Spike single, brownish to light green, androgynous, lax and few-flowered, the pistillate portion squarrose at maturity; scales oblong, acuminate, those of the pistillate flowers deciduous; perigynium shining brown to greenish, erect, but reflexed at maturity, membranaceous, elliptical, shortly stipitate, obsoletely two-nerved, glabrous, tapering into a beak with hyaline, obliquely cut orifice; stigmata two.

Hebetatæ: C. pulicaris L., *macrostylon* Lapeyr., *sagittifera* Lowe.

Phænocarpæ nob.

Spikes numerous, small, in a dense-flowered panicle or spicate inflorescence, sessile, contiguous, androgynous; bracts short, filiform; scales brownish; perigynia erect or somewhat spreading, ovate to orbicular, shining brown, spongious at base, plano-convex, nervose, with thin margins and a serrulate, bidentate beak; stigmata two.

Centrales: C. paradoxa Willd., *teretiuscula* Good., *paniculata* L., *appressa* R. Br., *virgata* Soland., *decomposita* Muehl.

Athrostachyæ nob.

Spikes several in a dense-flowered head, or the lower ones somewhat remote, sessile, gynæcandrous; bracts seldom conspicuous; scales brownish; perigynia erect, lanceolate to ovate or suborbicular, brown, plano-convex, nervose, more or less broadly winged with a long, serrulate, obliquely cut or bidentate beak; stigmata two.

Centrales: C. tribuloides Wahl., *Crawfordii* Fern., *scoparia* Schk., *Muskingumensis* Schw., *leporina* L., *athrostachya* Olney, *festiva* Dew., *petasata* Dew., *pinetorum* Liebm., *siccata* Dew., *pratensis* Drej., *adusta* Boott, *kaloides* Petrie, *viridis* Petrie, *ænea* Fern., *Liddonii* Boott.
Desciscentes: C. Bonplandii Kth.*

* =*illota* Bailey.

Pterocarpæ nob.

Spikes several, large, heavy and dense-flowered, contiguous or the lower ones remote, sessile, gynæcandrous; bracts inconspicuous; scales light brown or green; perigynia erect or slightly spreading, ovate to orbicular, light brown or greenish, compressed, nervose, broadly winged with a prominent, serrulate, bidentate beak; stigmata two.

Centrales: C. cristata Schw., *albolutescens* Schw., *mirabilis* Dew., *alata* Torr., *straminea* Willd., *straminiformis* Bail., *tenera* Dew., *Bicknellii* Britt., *silicea* Olney, *festucacea* Schk.
Desciscentes: C. Bebbii Olney, *foenea* Schk., *planata* Fr. et Sav., *neurocarpa* Maxim.

Microcephalæ nob.

Spike single, shining brown, very small, roundish to oval, dense-flowered, androgynous; scales broadly ovate, brown with hyaline margins; perigynia greenish, spreading at maturity, membranaceous, broadly ovate, sessile, nerveless, glabrous, tapering into a straight beak with hyaline orifice, slit on the convex face; stigmata two.

Hebetata: C. capitata L.

Cephalostachyæ nob.

Spikes several, reddish brown, androgynous, dense-flowered, sessile in a roundish or oblong head; bracts mostly inconspicuous, scales ovate to lanceolate, acute; perigynia shining brown, plano-convex, elliptical to ovate, sometimes turgid, stipitate to sessile, prominently many-nerved, scabrous along the beak, the orifice of which is bidentate or merely slit on the convex face; stigmata two.

Centrales: C. foetida All., *Colensoi* Boott, *stenophylla* Wahl., *chordorrhiza* Ehrh.

Sphærostachyæ nob.

Spikes several, androgynous, dense-flowered, sessile in a roundish head; bracts inconspicuous; scales broadly ovate, acute, shining brown with hyaline margins; perigynia yellowish, becoming fuscous at maturity, membranaceous, ovate, turgid, distinctly stipitate and diverging, nerveless or nearly so, glabrous or minutely scabrous along the prominent beak with obliquely cut orifice; stigmata two.

Centrales: C. incurva Lightf., *duriuscula* Mey.

II. Carices genuinæ.

Melananthæ Drej.

Spikes several, dense-flowered, peduncled, but mostly contiguous, gynæcandrous, or the terminal staminate and the

lateral pistillate; bracts conspicuous, sheathless; scales mostly dark; perigynia erect, often purplish spotted or black, elliptical, sessile, somewhat compressed, few-nerved, minutely granular and, sometimes, scabrous along the upper margins, the beak short, entire or emarginate; stigmata three.

Hebetatæ: *C. alpina* Sw., *melanantha* Mey., *melanocephala* Turcz.

Centrales: *C. atrata* L., *ovata* Rudge, *aterrima* Hppe., *bella* Bail., *nigra* All., *chalciolepis* Holm, *nivalis* Boott, *obscura* Nees, *Mertensii* Presc., *Parryana* Dew., *stylosa* Mey., *accedens* nob.,* *Raynoldsii* Dew., *holostoma* Drej., *Buxbaumii* Wahl., *bifida* Boott, *quadrifida* Bail., *Gmelini* Hook.

Desciscentes: *C. ustulata* Wahl., *venustula* sp. n., *Montanensis* Bail., *microchæta* sp. n., *Tolmiei* Boott, *nigella* Boott, *spectabilis* Dew.†

Microrhynchæ Drej.

Spikes several, often dense-flowered, sessile or short-peduncled, contiguous or, sometimes, remote, the terminal staminate, the lateral pistillate or the uppermost staminate or androgynous; bracts foliaceous, sheathless; scales mostly dark and obtuse; perigynia erect, mostly light green, roundish to elliptical, often stipitate, compressed, more or less prominently nerved, granular and often scabrous along the upper margins, the beak short, entire to emarginate; stigmata two.

Hebetatæ: *C. rufina* Drej.

Centrales: *C. stricta* Good., *angustata* Boott, *rhomboidea* Holm, *prionophylla* Holm, *cæspitosa* L., *lugens* Holm, *Yukonensis* Britt., *Hindsii* Clarke, *decidua* Boott, *vulgaris* Fr., *Thunbergii* Steud., *gymnoclada* Holm, *tricostata* Fr., *turfosa* Fr., *limula* Fr., *anguillata* Drej., *Groenlandica* Lge., *rigida* Good., *Fyllæ* Holm, *hyperborea* Drej., *Warmingii* Holm. *chimaphila* Holm, *stans* Drej., *aquatilis* Wahl., *sphacelata* sp. n., *chionophila* sp. n., *nudata* Boott, *consimilis* sp. n., *cyclocarpa* sp. n., *interrupta* Beklr., *acutina* Bail., *limnocharis* sp. n., *variabilis* Bail., *lenticularis* Michx., *torta* Boott, *acuta* L., *prolixa* Fr., *Bueckii* Wimm., *Sitchensis* Presc.,‡ *Nebrascensis* Dew., *pulchella* nob.,§ *notha* Kth., *laciniata* Boott.

Desciscentes: *C. scopulorum* Holm, *orbicularis* Boott.

Æorastachyæ Drej.

Spikes several, long and dense-flowered, long-peduncled, more or less drooping, remote, the terminal and uppermost lateral staminate, the others pistillate; bracts foliaceous and often very long, sheathless; scales mostly dark, acuminate to

* = *spreta* Bailey non Steudel.
† = *invisa* Bailey.
‡ = *Howellii* Bailey.
§ = *Hallii* Bailey non Boott.

aristate and longer than the perigynia; perigynia erect, mostly light green, oval to roundish, sessile, more or less turgid, faintly nerved, often granular, sometimes minutely scabrous along the upper margins, the beak short, entire to emarginate; stigmata mostly three.

Centrales: *C. subspathacea* Wormskj., *salina* Wahl., *hæmatolepis* Drej., *halophila* Nyl., *Drejeriana* Lge., *cryptocarpa* Mey., *capillipes* Drej., *Lyngbyei* Hornem., *macrochæta* Mey., *nesophila* sp. n., *scita* Maxim., *ternaria* Forst., *phacota* Sprgl., *prælonga* C. B. Clarke, *aperta* Boott,* *crinita* Lam., *gynandra* Schw., *maritima* L., *glaucescens* Ell., *pruinosa* Boott, *picta* Boott, *Kiotoensis* Fr. et Sav., *incisa* Boott, *Schottii* Dew.,† *magnifica* Dew., *lacunarum* sp. n., *Magellanica* Lam., *limosa* L., *laxa* Wahl., *rariflora* Sm., *stygia* Fr., *littoralis* Schw.

Cenchrocarpæ nob.

Spikes several, loose-flowered, peduncled, but erect, mostly remote, the terminal staminate, the lateral pistillate; bracts foliaceous, sheathing; scales dark or greenish, obtuse; perigynia erect, glaucous, oval to elliptical, nearly sessile, trigonous, turgid, more or less distinctly nerved, glabrous, the beak mostly short with entire or obliquely cut orifice; stigmata three.

Hebetatæ: *C. bicolor* All., *aurea* Nutt.

Centrales: *C. intermedia* Miq., *panicea* L., *livida* Willd., *Californica* Bail., *sparsiflora* Wahl., *tetanica* Schk., *Meadii* Dew., *Crawii* Dew., *vaginata* Tausch.,‡ *polymorpha* Muehl.

Desciscentes: *C. granularis* Muehl., *pallescens* L., *Torreyi* Tuckm., *rigens* Boott.

Lejochlænæ nob.

Spikes several, lax and few-flowered, peduncled, erect or somewhat drooping, remote, the terminal staminate, the lateral pistillate; bracts foliaceous, sheathing; scales hyaline, mucronate; perigynia erect, pale green, often glaucous, elliptical, stipitate, trigonous and turgid, many-nerved, glabrous, the beak distinct and often curved, the orifice oblique; stigmata three.

Hebetatæ: *C. polytrichoides* Muehl., *Geyeri* Boott, *multicaulis* Bail., *ambigua* Link.

Centrales: *C. digitalis* Willd., *plantaginea* Lam., *Careyana* Torr., *laxiflora* Lam., *Hendersonii* Bail., *platyphylla* Carey, *Hitchcockiana* Dew., *olbiensis* Jord., *laxiculmis* Schw., *ptychocarpa* Steud., *siderosticta* Hance.

Desciscentes: *C. grisea* Wahl., *oligocarpa* Schk., *conoidea* Schk., *glaucodea* Tuckm.

* = *turgidula* Bailey. † = *obnupta* Bailey. ‡ = *Saltuensis* Bailey.

Dactylostachyæ Drej.

Spikes several, lax and few-flowered, peduncled, erect or somewhat drooping, contiguous, seldom remote, the terminal staminate, the lateral pistillate; bracts sheathing, but often bladeless; scales reddish brown, obtuse; perigynia erect, dark green, elliptical, trigonous, stipitate, nervose, pubescent, the beak short, straight with oblique orifice; stigmata three.

Hebetatæ: *C. grallatoria* Maxim., *heteroclita* Fr. et Sav., *humilis* Leyss.

Centrales: *C. digitata* L., *ornithopoda* Willd., *ornithopodioides* Hsm., *concinna* R. Br., *amphora* Fr. et Sav., *Brenneri* Christ., *pediformis* Mey., *lanceolata* Boott, *Richardsonii* R. Br., *conica* Boott, *pedunculata* Muehl., *Halleriana* Asso, *Boottiana* Benth., *Baltzellii* Chapm., *Linkii* Schk., *illegitima* Cesati, *cryptostachys* Brongt.

Desciscens: *C. triquetra* Boott.

Trachychlænæ Drej.

Spikes several, cylindrical, dense-flowered, peduncled and nodding, remote or the upper ones contiguous, the terminal staminate, the lateral androgynous or wholly pistillate; bracts foliaceous with very short sheaths; scales dark, acute; perigynia somewhat spreading at maturity, purplish spotted, ovate to subglobose, sessile, faintly nerved, minutely hairy or scabrous, the beak short, emarginate to subbidentate; stigmata mostly three.

Centrales: *C. glauca* Scop, *virescens* Muehl., *triceps* Michx., *trinervis* Degl., *hispida* Schk., *setigera* Don.

Desciscens: *C. spissa* Bail.

Microcarpæ Kuekthl.

Spikes several, cylindrical and often very long, more or less dense-flowered, peduncled, nodding, remote or the upper ones contiguous, the terminal staminate, the lateral pistillate or, sometimes, the upper ones androgynous; bracts foliaceous with long sheaths; scales hyaline to light green or brown, acute; perigynia often small to the size of the plants, somewhat spreading at maturity, light green, elliptical, trigonous and sometimes turgid, sessile, nervose, glabrous, the beak short with the orifice entire, oblique; stigmata three.

Centrales: *C. microcarpa* Bertol., *Mendocinensis* Olney, *strigosa* Huds., *gracillima* Schw., *maxima* Scop.

Desciscentes: *C. oxylepis* Torr. et Hook., *Davisii* Schw. et Torr., *formosa* Dew.

Athrochlænæ nob.

Spike single, androgynous, dense-flowered, the pistillate portion squarrose at maturity: scales lanceolate or oblong, obtuse, deciduous; perigynia shining brown, erect, but reflexed at

maturity, membranaceous, fusiform or ovate, prominently stipitate, nerveless, glabrous, tapering into a long beak with the orifice hyaline and obliquely cut; stigmata mostly three.

Hebetatæ: C. pyrenaica Wahl., *nigricans* Mey.

Stenocarpæ nob.

Spikes several, slender and not very dense-flowered, borne on long peduncles, often drooping, remote or the upper ones contiguous, the terminal and, sometimes, the uppermost lateral staminate, the others pistillate; bracts mostly filiform and short, sheathing; scales purplish or brown, acuminate; perigynia purplish, slightly spreading, membranaceous, attenuated at both ends, triquetrous, faintly few-nerved, glabrous or a little scabrous above, the beak prominent, bidentate with erect teeth or obliquely cut, often hyaline; stigmata three.

Hebetatæ: C. lejocarpa Mey., *circinata* Mey., *hakkodensis* Franch., *mucronata* All., *curvula* All.

Centrales: C. sempervirens Vill., *frigida* All., *ferruginea* Scop., *tristis* M. Bieb., *luzulæfolia* W. Boott, *luzulina* Olney, *ablata* Bail., *firma* Host., *hirtella* Drej., *hispidula* Gaud., *gynodynama* Olney, *tenax* Reut., *setosa* Boott, *juncea* Willd., *psychrophila* Nees, *petricosa* Dew., *stenantha* Fr. et Sav.

Desciscentes: C. tenuis Host, *misandra* R. Br., *cruenta* Nees, *longicruris* Nees.

Podogynæ nob.

Spikes several, the terminal and, sometimes, the uppermost lateral (1 or 2) staminate, clavate, long-peduncled, the others pistillate, very robust, dense-flowered, globose to ovoid or cylindrical, long-peduncled, drooping, contiguous or somewhat remote; bracts foliaceous, narrow, sheathless; scales purplish black, lanceolate, acuminate to emarginate, often aristate; perigynia light green, purplish above, spreading on very long, ciliate stipes, membranaceous, lanceolate, compressed, two-nerved, ciliate, the beak prominent, bidentate; stigmata two.

Centralis: C. podogyna Fr. et Sav.

Lamprochlænæ Drej.

Spikes several, short and few-flowered, sessile or peduncled, erect, contiguous, the terminal staminate, the lateral pistillate; bracts narrow, sheathing; scales brownish, broad, mucronate, the margins hyaline; perigynia shining brown, erect, ovate or elliptical to almost orbicular, somewhat turgid, trigonous, sessile, faintly nerved, glabrous to minutely scabrous, the beak short with hyaline, oblique orifice; stigmata three.

Hebetatæ: C. rupestris All., *obtusata* Liljebl.

Centrales: C. obesa All., *nitida* Host, *pedata* Wahl., *eburnea* Boott, *alba* Scop., *villosa* Boott, *pilosa* Scop., *depauperata* Good.

Chionanthæ nob.

Spikes several, snow-white, androgynous, the staminate portion dense-flowered, the pistillate few-flowered, almost sessile in a roundish or oval head; bracts foliaceous with long and green blades; scales white, ovate, acute or obtuse; perigynia white with a few minute, purplish streaks and spots above, oblong, trigonous, sessile, two-nerved, glabrous, somewhat inflated, the beak very short, entire, but erosely denticulate around the orifice; stigmata three; rhacheola not developed.

Centralis: C. Baldensis L.

Leucocephalæ nob.

Spike single, snow-white, androgynous, dense-flowered; scales of staminate flowers elliptical, those of the pistillate broad and obtuse to emarginate, all white; perigynia somewhat spreading, membranaceous, whitish, elliptical, sessile, faintly nerved, glabrous, the beak very short, obliquely cut; stigmata three; rhacheola well-developed; leaves destitute of sheath, ligule and midrib.

Centralis: C. Fraseri Andrews.

Elynanthæ nob.

Spike single, androgynous, the pistillate portion few-flowered; scales brown, very broad, amplectent; perigynia membranaceous, whitish to brown, erect, oval to obovoid, obtusely triangular in cross-section, sessile, faintly two-nerved, pubescent above, the beak short, but distinct, with hyaline entire or obliquely cut orifice; stigmata three.

Hebetatæ: C. filifolia Nutt., *elynoides* Holm.

Sphæridiophoræ Drej.

Spikes several, the terminal staminate, clavate, the lateral pistillate and roundish, few-flowered, sessile or the lowest one peduncled, erect, contiguous to remote; bracts foliaceous, narrow, sheathless; scales brownish or purplish, acuminate, often mucronate; perigynia dark green, slightly spreading, elliptical to obovate or globose, trigonous, sessile or shortly stipitate, obscurely nerved, more or less pubescent, the beak short, emarginate to bidentate with the teeth erect; stigmata three.

Hebetatæ: C. scirpoidea Michx.

Centrales: C. ericetorum Poll., *membranacea* Poll., *polyrrhiza* Wallr., *præcox* Jacq., *montana* L., *Moorcroftii* Boott, *varia* Muehl., *communis* Bail., *pilulifera* L., *breviculmis* R. Br., *deflexa* Hornem., *Rossii* Boott, *pennsylvanica* Lam., *verecunda* nob.,* *turbinata* Liebm., *Floridana* Schw., *leucodonta* nob.†

* = *inops* Bail. non Kunze.

† = *rigens* Bailey non Boott.

Desciscentes: C. tomentosa L., *globularis* L., *Chapmanii* Sartw., *dasycarpa* Muehl., *Whitneyi* Olney, *pubescens* Michx., *Coulteri* Boott, *pisiformis* Boott.

Trichocarpæ nob.

Spikes several, cylindrical and more or less robust, dense-flowered, sessile or the lowest ones peduncled, but erect, remote, the terminal and uppermost lateral staminate, the others pistillate; bracts foliaceous, often very long, sheathing; scales purplish or brown, mucronate to aristate; perigynia brownish or dark green, erect, ovate to ovate-lanceolate or elliptical, more or less turgid, sessile, nervose, more or less pubescent, prominently beaked, the beak bidentate with spreading teeth; stigmata three.

Centrales: C. vestita Willd., *Yosemitana* Bail., *hirtissima* W. Boott, *Oregonensis* Olney, *hirta* L., *filiformis* L., *lanuginosa* Michx., *evoluta* Hartm., *Houghtonii* Torr., *trichocarpa* Muehl., *aristata* R. Br., *striata* Michx., *Pierotii* Miq., *pumila* Thunbg., *Wahuensis* Mey., *psilocarpa* Steud.

Desciscentes: C. nutans Host, *paludosa* Good., *riparia* Curt., *subdola* Boott, *trifida* Cavan., *Songorica* Karel. et Kir., *baccans* Nees, *Myosurus* Nees, *composita* Boott, *brunnea* Thunbg.

Echinochlænæ nob.

Spikes several, cylindrical, dense-flowered, sessile and erect, remote, the terminal staminate or sometimes andro- to gynæcandrous, the lateral pistillate, often with a few staminate flowers at the base or apex; bracts foliaceous and often very long, sheathing; scales light purplish to brown, mucronate to aristate; perigynia shining reddish brown, seldom grayish, erect, elliptical to oval, plano-convex or trigonous, sessile, nerved, the beak short, bidentate and prominently spinulose; stigmata two or three.

Centrales: C. lucida Boott, *Lambertiana* Boott, *Buchanani* Berggr., *Wakatipu* Petrie, *dipsacea* Berggr., *dissita* Sol., *uncifolia* Cheesem., *Petriei* Cheesem., *testacea* Sol., *Neesiana* Endl.

Desciscentes: C. decurtata Cheesem., *Raoulii* Boott., *comans* Berggr., *cirrhosa* Berggr.

Hymenochlænæ Drej.

Spikes several, cylindrical, slender and not very dense-flowered, peduncled and drooping, remote, the terminal staminate, the lateral pistillate; bracts foliaceous, the lowest sheathing; scales hyaline with green, excurrent midrib; perigynia light green, erect to slightly spreading, membranaceous, oval to ellip-

tical, turgid and trigonous, stipitate, faintly nerved or nerveless, scabrous along the prominent, bifid or bidentate beak with hyaline orifice; stigmata three.

Hebetatæ: *C. rhizopoda* Maxim., *Steudelii* Kth., *Willdenowii* Schk., *Backii* Boott, *macroglossa* Fr. et Sav., *filipes* Fr. et Sav. *parciflora* Boott, *longerostrata* Mey.

Centrales: *C. arctata* Boott, *vacillans* Sol., *debilis* Michx., *silvatica* Huds., *elata* Lowe, *Cherokeensis* Schw., *Arnellii* Christ, *transversa* Boott, *curvicollis* Fr. et Sav., *anisostachys* Liebm., *longirostris* Torr., *Turczaninoviana* Meinsh., *flexilis* Rudge, *capillaris* L., *Krausei* Boklr., *Williamsii* Britt.

Desciscentes: *C. Assiniboinensis* W. Boott, *prasina* Wahl., *Chinensis* Retz., *scabrata* Schw., *confertiflora* Boott, *dispalatha* Boott, *olivacea* Boott, *amplifolia* Boott, *speciosa* Kth., *Jamesonii* Boott.

Spirostachyæ Drej.

Spikes several, cylindrical, but rather short, dense-flowered, peduncled, but mostly erect, remote, the terminal staminate, the lateral pistillate; bracts foliaceous, sheathing; scales brownish, acuminate; perigynia mostly greenish, more or less spreading at maturity, oval to elliptical, somewhat turgid, sessile, nervose, glabrous or scabrous along the beak, which is quite long and bifid; stigmata three.

Centrales: *C. Hornschuchiana* Hppe., *diluta* M. Bieb., *punctata* Gaud., *distans* L., *binervis* Sm., *lævigata* Sm., *Camposii* Boiss. et Reut., *Lemmonii* W. Boott, *extensa* Good., *Mairii* Coss. et Germ., *aphanolepis* Fr. et Sav., *trichostyles* Fr. et Sav., *Ringgoldiana* Boott, *Michelii* Host, *brevicollis* D. C., *flava* L., *Oederi* Retz., *viridula* Michx., *Morrowii* Boott.

Desciscentes: *C. squarrosa* L., *typhina* Michx., *stenolepis* Torr.

Echinostachyæ Drej.

Spikes several, cylindrical, robust and dense-flowered, the terminal staminate often gynæcandrous, the lateral pistillate, peduncled and drooping, contiguous, squarrose at maturity; bracts foliaceous and very long, the lowest one sheathing; scales lanceolate, light brown or greenish, mucronate to aristate; perigynia greenish, reflexed at maturity, membranaceous, ovate to elliptical-ovate, somewhat inflated, trigonous, stipitate, prominently nerved, glabrous, the beak distinct, bidentate; stigmata three.

Hebetatæ: *C. microglochin* Wahl., *pauciflora* Lightf.

Centrales: *C. subulata* Michx., *Pseudocyperus* L., *Forsteri* Wahl., *alopecuroides* Don, *Doniana* Sprgl., *fascicularis* Sol., *Schweinitzii* Dew., *hystricina* Muehl., *retrorsa Schw.*

Physocarpæ Drej.

Spikes several, cylindrical, sessile or the lowermost peduncled, erect, remote, the terminal and, sometimes, the uppermost lateral staminate, the others pistillate; bracts foliaceous, but mostly narrow, sheathless; scales lanceolate, acuminate, brownish or purple; perigynia shining, light green to dark purplish, almost black, spreading, but not reflexed, membranaceous, globular to oblong-elliptical, membranaceous, inflated, sessile, nervose, glabrous, the beak short, bidentate to merely emarginate; stigmata three, seldom two.

Hebetatæ: *C. Engelmannii* Bail.
Centrales: *C. ambusta* Boott, *oligosperma* Michx., *miliaris* Michx., *ampullacea* Good., *lævirostris* Fr., *rotundata* Wahl., *utriculata* Boott, *physocarpa* Presl., *physochlæna* sp. n., *vesicaria* L., *pulla* Good., *Olneyi* Boott, *mirata* Dew.,* *compacta* R. Br.

Physocephalæ Bail. ex p.

Spike single, oval to globose, androgynous; scales lanceolate, reddish brown with broad hyaline margins; perigynia reddish brown, spreading, membranaceous, much inflated, sessile, faintly nerved, glabrous, the beak short with hyaline, obliquely cut orifice; stigmata three.

Hebetata: *C. Breweri* Boott.

Rhynchophoræ nob.

Spikes several, cylindrical, very robust and dense-flowered, sessile or short peduncled, mostly erect, contiguous, the terminal staminate, the others pistillate or, sometimes, the uppermost lateral staminate; bracts foliaceous and very long, the lowermost with a short sheath; scales pale, lanceolate, aristate or mucronate; perigynia greenish, erect or ascending, membranaceous, ovate, much inflated, stipitate, strongly nerved, glabrous or scabrous along the very prominent beak, which is sharply bidentate; stigmata three.

Hebetatæ: *C. uda* Maxim., *Michauxiana* Bcklr., *folliculata* L.
Centrales: *C. intumescens* Rudge, *Grayii* Carey, *Idzuroei* Fr. et Sav., *monile* Tuckm., *Halei* Carey, *bullata* Schk., *Tuckermannii* Boott, *lupulina* Muehl., *gigantea* Rudge, *lurida* Wahl., *Dickinsii* Fr. et Sav.
Desciscens: *C. rhynchophysa* Mey.

Brookland, D. C., Aug., 1903.

* = *exsiccata* Bailey.

Art. XLV.—*Action of Ultra-Violet Light upon Rare Earth Oxides;* by Charles Baskerville.

During the extended investigations of the action of ultra-violet light, cathode rays, Röntgen rays, and the emanations of radium upon gems and minerals in the Morgan-Tiffany gem and Morgan-Bement mineral collections in the American Museum of Natural History, a number of rare earth oxides were subjected to the action of ultra-violet light.* The following oxides were exposed to ultra-violet light produced by a Piffard lamp:

Gadolinium oxide (prepared by Waldron Shapleigh).†
Lanthanum oxide (prepared by H. S. Miner).
Neodidymium oxide (prepared by a method of Baskerville and Stevenson).
Praseodidymium oxide (prepared by the method of Baskerville and Turrentine).
Cerium oxide (prepared by H. S. Miner).
Samarium oxide (prepared by Waldron Shapleigh).
Thorium dioxide (chemically pure according to general acceptation previous to 1900, prepared by Baskerville and Davis).
Yttrium oxide (prepared by Waldron Shapleigh).
Yttrium, erbium, and ytterbium oxides mixed (prepared by H. S. Miner).
Erbium oxide (bought from Kahlbaum).
Erbium group oxides (prepared by Benton Dales).
Uranium oxide (prepared by S. Auchmuty Tucker).
Uranium oxide (prepared by S. Auchmuty Tucker).
Yttrium oxide (prepared by Dennis and Dales).
Ytterbium oxide (prepared by Benton Dales).
Titanium dioxide (bought from Eimer and Amend).
Zirconium dioxide (prepared by Venable and Baskerville).

Only two of the above oxides responded at all to the action of ultra-violet light, namely, zirconium and thorium dioxides, which phosphoresced strongly. The thorium dioxide remained luminous in the dark for a greater length of time. The zirconium dioxide showed no radio-activity when tested by the electrical and photographic methods. It is strange that the two rare earths forming normally the dioxide are the only ones to exhibit this property. This will be investigated further.

* Reported to New York Academy of Sciences, Oct. 6, 1903.

† My thanks are due to Doctors Miner, Tucker and Dales for the generous loan of preparations.

In view of the fact that these two earths give this characteristic response to ultra-violet light, it became immediately of interest to learn the effect of the light upon minerals carrying those substances in different proportions. The following minerals were subjected to the action of ultra-violet light without a single one of them giving either fluorescence or phosphorescence:

SAMARSKITE, Berthier Co., Que.

THORITE (Orangite), Arendal, Norway.
" Barkevik, Norway.
" (Auerlite), Green River, N. C.

SIPYLITE, Amherst Co., Va.

COLUMBITE, Portland, Conn.

MONAZITE, Arendal, Norway.
" Zlatoust, Ural.
" 171st St. and Washn. Ave., New York.
" Amelia C. H., Va.
" Alexander Co., N. C.

Monazite sand, Rio, Brazil.

MONAZITE, Tyedestrand, Norway.

XENOTIME, Cheyenne Canyon, Colo.
" Alexander Co., N. C.
" Hitteröe, Norway.

EUXENITE (in Samarskite), Mitchell Co., N. C.

AESCHYNITE, Hitteröe, Norway.

POLYCRASE, nr. Marietta, S. C.

FERGUSONITE, Llano Co., Texas.
" Ytterby, Sweden.

The extended investigation of the action of ultra-violet light upon minerals carried out by Dr. Geo. F. Kunz and the writer will shortly be published in full.

University of North Carolina, Sept. 15th, 1903.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A New Method for the Determination of the Faintest Traces of Arsenic.*—Armand Gautier, who has devoted much attention to the determination of small amounts of arsenic, and to the distribution of this element, has now described a very simple and accurate method for determining the most minute quantities of it. The method, which is particularly well adapted to the examination of chlorides, while the older methods present difficulties in such cases, consists in adding, under proper conditions, specially purified ferric sulphate solution to the liquid to be tested, boiling, and thus precipitating all the arsenic with the basic ferric salt; then dissolving the filtered precipitate in sulphuric acid and using the resulting solution directly in the Marsh apparatus.

The method is so delicate that $0{\cdot}001^{mg}$ of arsenic in a liter of water is entirely recovered by means of it. A sample of sea-water taken at 30^{km} from the coast of Brittany, at a depth of 5^{m} gave $0{\cdot}010^{mg}$ of arsenic per liter; water from near the Azores, at 10, 1335 and 5943^{m} depth gave 0·025, 0·010 and $0{\cdot}080^{mg}$ per liter; water from a salt spring at Missery gave $0{\cdot}010^{mg}$ per liter; various samples of common salt gave from 0·001 to $0{\cdot}045^{mg}$ in 100^{g}, while a sample of the same substance from a volcanic fissure at Vesuvius gave $0{\cdot}175^{mg}$ in 100^{g}. Various reagents supposed to be pure were found to contain arsenic; thus water distilled from copper and glass after the addition of sodium carbonate gave 0·0007 and $0{\cdot}0011^{mg}$ per liter, while so-called pure ammonia-bicarbonate of soda, potassium nitrate and sulphate, etc., gave appreciable quantities of the element.—*Bulletin*, xxix, 859. H. L. W.

2. *The Influence of Small Quantities of Water in bringing about Chemical Reactions between Salts.*—Many experimenters have investigated the influence of traces of moisture in reactions between gases, but apparently no one has hitherto made similar experiments with solids. Perman has therefore made a number of experiments in this direction, and has chosen for this purpose the salts of lead and mercury mixed with salts of potassium, usually the iodide, where the progress of a reaction would be indicated by a change of color. Equivalent quantities of lead chloride and potassium iodide were dried over strong sulphuric acid and then mixed. It was found that after drying forty-eight hours no visible change took place on mixing the salts, but on keeping the mixture a week in a sealed flask a faint yellow color appeared, which, after some months, became bright yellow. Attempts were made to find how much water was necessary in order to make the reaction immediately visible; the results were not very concordant, but indicated that about $0{\cdot}5^{mg}$ was necessary when 2^{g} of potassium iodide and an equivalent quantity of

lead chloride were mixed in a glass flask of 200^{cc} capacity. It was found that lead formate and lead nitrate act in a similar way to the chloride, when mixed with potassium iodide, while lead sulphate reacts much more slowly, although exposed to the air, and the carbonate and oxide react very slowly indeed.

When mercuric chloride and potassium iodide were treated in exactly the same way as has been described, a strong coloration was produced on mixing, but by drying with specially prepared phosphorus pentoxide, the mixture obtained has been kept for some months without change. Mercuric cyanide showed no reaction with potassium iodide, while mercuric chloride and potassium chromate reacted very slowly, although exposed to the air.

The author believes that there is no reason for thinking that the reactions take place in any way essentially different from similar reactions in solution, except in their slowness. He observes that mercuric chloride, which is ionized but slightly in solution, appears to react more rapidly than the readily ionized lead chloride; hence it appears that ionization cannot be the cause of the difference, and the conclusion is reached that the specific reaction velocity seems to be the real determining factor.—*Chem. News*, lxxxviii, 197. H. L. W.

3. *The Determination of Argon in the Atmosphere.*—Moissan has determined the amount of argon in more than twenty samples of air from many different localities. The oxygen and nitrogen of the air were absorbed by hot mixtures of lime and metallic magnesium, and the last traces of these gases, as well as of hydrogen, were removed by the action of hot metallic calcium which this investigator has succeeded in preparing in a state of great purity. The description of the method of analysis indicates that the results are very exact. With the exception of a single analysis, where 0·9492 per cent of argon was found in a sample of air from the Atlantic Ocean, the results are very concordant, and show that the amount of argon in the air is very constant, whether taken on land or sea, or at high or low altitudes. For instance, the percentage of argon found in another Atlantic Ocean sample was 0·9318; two from Paris, 0·9337 and 0·9319; from London, 0·9325; from Berlin, 0·9323; two from the summit of Mt. Blanc, 0·9352 and 0·9327; from St. Petersburg, 0·9329; from Moscow, 0·9323; from the summit of Mt. Pelée, 0·9366; from the Gulf of Naples, 0·9326; and from Venice, 0·9357. The author sums up by saying that samples of air collected in the interior of continents at altitudes from 0 to 5800^{m} show in 100^{cc} an amount of argon which varies from 0·932 to 0·935^{cc}, while samples of air from the surface of different seas show in general a slightly larger amount of argon but are also very constant except in the case of a single sample. The author states also that these researches have confirmed the important views of Dumas and Boussingault concerning the constancy in composition of the terrestrial atmosphere.—*Comptes Rendus*, cxxxvii, 600. H. L. W.

4. *A New Method for Detecting Chlorides, Bromides and Iodides.* — BENEDICT and SNELL have devised the following method for the purpose under consideration: The reagents used are potassium iodate of one-tenth, potassium iodide of one-fifth and nitric acid of five times "molar" concentration (sp. gr. of HNO_3 1·18). The operations are carried out in a rather wide test-tube. To the neutral solution acetic acid and KIO_3 are added. If iodine is thus found the liquid is boiled with addition of small quantities of KIO_3 until no further coloration is produced. To the liquid is then added nearly one-half its volume of dilute nitric acid. Coloration shows bromine, which may be confirmed by shaking a portion with chloroform or carbon disulphide. The main solution is boiled until colorless, 1 or 2^{cc} of KI are added, and the liquid is boiled again until colorless. An equal volume of concentrated nitric acid is then added together with a few drops of silver nitrate solution. A white precipitate, insoluble on warming, shows silver chloride. The concentrated nitric acid is added to prevent the precipitation of silver iodate in case there should be iodate still left in the solution after the treatment with potassium iodide. When a thiocyanate is present, the test for iodine is made in a portion after the addition of sodium acetate. If salts of other acids are present, the silver halides are first precipitated, filtered and washed, then decomposed with zinc and dilute sulphuric acid, neutralized, filtered, and treated as above. The method is said to give very satisfactory results, but it is evident that considerable care would be necessary in making the test for iodine, since other reducing agents would give the same reaction as an iodide.—*Jour. Amer. Chem. Soc.*, XXV, 809. H. L. W.

5. *Quartz Glass.* — A very full account of the behavior of this material has been given by H. HERAEUS before the International Congress of Practical Chemistry held lately in Berlin. The history of the working of quartz was related. Experiments were made as early as 1839; and the prominent experimenters in the subject have been Gaudin, Gautier, Boys, Dufour, Hutton, Shenstone, and, also, Heraeus.

The chemical relations of quartz are especially interesting. Quartz vessels are unaffected by water, acids and salt solutions; but are affected by alkaline fluids. At high temperatures all oxides are dangerous for the vessels. One therefore should carefully clean such vessels; and abstain from touching them with the fingers. If one encloses a quartz tube in an electric furnace and heats it for several hours to about 1300°, its surface remains clear and limpid when it is taken out of the furnace. With a microscope, however, one perceives a slight change of the surface; when it cools sufficiently to be taken by the hand the whole surface becomes quickly clouded and non-transparent. Heraeus attributes this to a vitrification of the amorphous silicate and is a surface action. When this experiment is repeated in a closed platinum cylinder no such silicate is formed. At high tempera-

tures the quartz is attacked by phosphoric acid; according to Prof. Mylius, crystallized silicic-phosphoric acid is formed—this also happens with the melting of phosphoric-ammonia-magnesia in phosphoric acid determinations.

Quartz at highest temperatures is not attacked by metals free from oxides. It allows a slow passage of hydrogen. This is much less than in the case of platinum and enters at a higher temperature than in the case of the latter. Shenstone states that a mixture of nitrogen and oxygen in quartz vessels, heated to the melting point of platinum, is converted into hyponitrous acid. The temperature of melting of quartz is about 2000°. The coefficient of expansion is extraordinarily low—far lower than with any known material—and makes the quartz very suitable for thermometers which are now constructed by Dr. Siebert and Kuhn.

If one passes an electric discharge through a rarified quartz tube a strong odor of ozone is noticed. This is a very noticeable phenomenon with Arons mercury lamp enclosed in a quartz vessel. It is impossible to remain long near such lamp. This behavior of quartz was first noticed by Lenard, Ann. d. Physik, 503, 1900.—*Deutsche Mechaniker Zeitung*, Oct. 1, 1903. J. T.

6. *Absorption of Ultra-Violet Rays by Ozone.* — It is well known that the earth's atmosphere absorbs the ultra-violet rays below $\lambda = 3000$. W. N. Hartley found an absorption band of ozone at a mean wave-length of $\lambda = 2560$. EDGAR MEYER has taken up this subject and has obtained quantitative results by a new method. The new feature of the method consists in the employment of the photoelectric photometer of Kreusler to determine the regions of absorption. This photometer is described in the Ann. der Phys., vi, p. 398, 1901. It was found that the extinction coefficient of ozone increased with the amount of ozone, and Hartley's absorption band was rediscovered; but at a mean wave length of $\lambda = 2580$.

Since the earth's atmosphere strongly absorbs the ultra-violet rays, Meyer discusses the question whether this absorption is largely due to ozone. A. Levy concludes from his ozonometric measurements, extended over twenty years, that 100^{cb} of air contains $1{\cdot}65^{mg}$ of ozone. Meyer takes this result, makes the assumption that it is the ozone which absorbs the short waves, and computes the energy distribution in the solar spectrum by the aid of Planck's formula. The graphical representation of the results show that in the region 2200 there is more than twice the energy that appears at wave-length 2500. The quantitative determination of the absorption bands of ozone are more conclusive than the determination of the question whether the ozone is chiefly instrumental in the absorption of the short waves of light.—*Ann. der Physik*, No. 12, 1903, pp. 849–859. J. T.

7. *Induced Thorium Activity.* — Thorium possesses, in common with radium, two kinds of radiation; the straight line radiations and the so-called emanation. Rutherford attributes the induced activity to this emanation. If one brings the source of

the radio-active emanation into an electric field the greater portion condenses on the negative electrode which then becomes temporarily active. According to J. J. Thomson and Rutherford the radio-active emanation throws off a negative electron that ionizes the air, resulting in a positive charge which wanders to the cathode. Curie sees in the emanation only a peculiar kind of streaming out of energy, a condition of matter in which possibly a gas is the bearer of the energy. Rutherford attributes the phenomenon to a radio-active gas of the argon group. The radio-activity is the indication of a series of atomic reactions. Out of thorium, for instance, comes ThX, from the latter arises the emanation and this again suffers a sub-atomic chemical change with formation of induced activity. F. von Lerch studies induced activity without regard to any especial hypothesis and sums up his results at the end of his article. One of his conclusions is that palladium appears to absorb the emanations. He also concludes that his experiments show the material nature of induced activity.—*Ann. der Physik*, No. 12, 1903, pp. 745–766.

J. T.

8. *Effect of Pressure on Arc Spectra.* — J. E. Petavel and R. S. Hutton find that at about 44 atmospheres a number of iron lines in the ultra-violet above 3800 are very strongly reversed. The absorption due to the presence of iron vapor results in a diminution of intensity toward the violet end of the spectrum, It was found that certain of the lines appear in the vacuum glow spectrum with their characteristic intensity, neighboring lines of almost equal importance in the ordinary arc and self-induction spark have so greatly diminished as to be quite invisible, the effect, therefore, is in no way connected with the actual exposure of the photograph or the intensity of the light.—*Phil. Mag.*, November, 1903, pp. 569–577. J. T.

II. Geology and Mineralogy.

1. *United States Geological Survey*, C. D. Walcott, Director.—Among recent publications of the Geological Survey are the following:

Water Supply and Irrigation Papers, No. 80. The Relation of Rainfall to Run-off; by George W. Rafter. 102 pp., 23 figs. The relation of rainfall to run-off is influenced by many complex factors and no general expression is possible. Rainfall records covering less than 35 years are not reliable, and no satisfactory run-off records are at hand. Mr. Rafter undertakes to establish a more rational theory than has heretofore been proposed.

No. 81. California Hydrography; by Joseph Barlow Lippincott. 478 pp., 4 figs. The data covering the water supply of California has been collected from various sources.

Nos. 82, 83, 84. Progress of Steam Measurements for the Calendar year 1902; by F. H. Newell. No. 82 (195 pp.) covers the Northern Atlantic coast and St. Lawrence Drainage; No. 83 (300

pp.) the Southern Atlantic, Eastern Gulf, Eastern Mississippi and Great Lakes Drainage; No. 84 (196 pp.) the Western Mississippi and Western Gulf Drainage.

BULLETINS No. 212. Oil fields of the Texas-Louisiana Gulf Coastal Plain; by C. W. HAYES and WILLIAM KENNEDY. 170 pp., 11 pls., 12 figs. The geology of the Gulf coastal plain is described and also the detailed geology of the oil pools of the different districts. The elliptical domes which have furnished the conditions for oil accumulation are of a different class from the anticlines of the Appalachian region and "could scarcely have been produced by horizontal compression." The oil of this district is "derived, in part at least, from the action of decomposing organic matter, both animal and vegetable, but chiefly the latter, upon gypsum." The "oil ponds" in the Gulf water are shown not to be produced by diatoms but 'derived from oil that is either indigenous in the mud or derived from underlying rocks.'

No. 214. Geographic Tables and Formulas; by SAMUEL S. GANNETT. 284 pp. The tables and formulas used by topographers in the field and the office have been brought together in convenient form.

No. 215. Catalogue and Index of the Publications of the U. S. Geological Survey 1901 to 1903; by PHILIP C. WARMAN. 234 pp.

No. 216. Primary Triangulation and Primary Traverse, Fiscal year 1902–03; by S. S. GANNETT. 211 pp., 1 map.

PROFESSIONAL PAPER, No. 15.—The Mineral Resources of the Mount Wrangell District, Alaska; by W. C. MENDENHALL and F. C. SCHRADER. 68 pp., 10 pls., 5 figs. The Mount Wrangell district has important deposits of copper and of gold. The copper, chiefly bornite, occurs along the contact between the Nikolai greenstone (Carboniferous, 4000 ft. thick) and the Chitistone limestone (Permian) and has been concentrated from the greenstones. Gold to the value of $225,000 was mined in the Chestochina field in 1902. "The region is extensively glaciated but the present glaciers are but insignificant remnants of their predecessors," and the surface forms of the ores have been removed.

PROFESSIONAL PAPER, No. 13.—Drainage Modifications in Southeastern Ohio and Adjacent Parts of West Virginia and Kentucky; by W. G. TIGHT. 108 pp., 17 pls., 1 fig. Taken in connection with Leverett's monograph on the Erie and Ohio Basins (U. S. G. S. Mon. XLI), Professor Tight's paper gives a detailed account of the interesting drainage modifications of the upper Ohio and its tributaries. A very extensive rearrangement of divides and basins has taken place, the general history of which is outlined as follows: the high level valleys are pre-Glacial; the deflection of the streams producing the present drainage system was accomplished by the first advance of the ice sheet (pre-Kansan ?); the extensive erosion of the valleys to depths below present drainage lines was accomplished during a long interglacial interval; these interglacial valleys were partially filled by deposits from flooded streams and afterwards partially recut

during the last Glacial epoch ; post-Glacial erosion is represented by the channels cut in the floor of these deposits since the waters have acquired their present volume. "The Ohio River Valley from New Martinsville to Manchester is of interglacial origin."

2. *Nebraska Geological Survey.*—E. H. BARBOUR, State Geologist. Volume I, 1903. 242 pp., 166 figs., 13 pls.—For a number of years geological exploration has been carried on in Nebraska by Professor Barbour, both at private expense and as director of the Morrill Geological Expedition. The State has now made an appropriation for the publication of reports. The present report contains chapters on Hydrography, on Geology including mineral resources, on Soils, and on the Geology of Jefferson County. Considerable study has been made of the drainage conditions and attention is called to the down-stream shifting of the Loup tributaries of the Platte, and to the local artesian and salt water basins. The geological formations represented are : Carboniferous 1200 ft. (8 to 10 inches of coal); Permo-Carboniferous, 200 ft.; Dakota, water-bearing beds, 250 ft.; Benton, 200 ft.; Niobrara; Pierre, 100 to 3000 ft.; Oligocene, Bad Lands, 600 to 800 ft.; Miocene, Butte Sands, 500 to 600 ft.; Pliocene, 200 ft.; Pleistocene, drift and loess. Volcanic dust is found widely distributed over the State.

3. *The Geological Structure of Monzoni and Fassa ;* by MARIA M. OGILVIE GORDON. Trans. Edinb. Geol. Soc., vol. viii, special pt., pp. 179, with maps, figs. and pls. 1902–3.—The Monzoni region has long been known as a classic field of research in varied branches of geology, and since the publication of Brögger's remarkable memoir (Die Eruptionsfolge der Triadischen Eruptivgesteine bei Predazzo in Süd-Tyrol) numerous papers dealing with features of the area and especially with the problems of the igneous rocks have appeared. In some instances these have led to discussions which have become rather acrimonious in character, the varied opinions apparently having arisen from insufficient study of the field relationships.

All this makes the present work by Mrs. Ogilvie Gordon the more timely as it consists mainly of the results of detailed and patient study and mapping of the field relations, and her conclusions, which are not based upon generalities, but upon observed facts, throw a flood of light upon the structure of the area and will prove of service in helping to solve similar problems elsewhere. The important features of her paper are the location and description of the various folds, and systems of faults, and the relation which the igneous intrusions bear to these fold and fault systems. The intrusions she believes to be of Tertiary age.

L. V. P.

4. *North American Plesiosaurs ;* by S. W. WILLISTON. Publications of Field Columbian Museum. Geological series, vol. ii, No. 1, 77 pp., 29 pls.

This paper has been presented by the author as part of one of a series of monographic studies on the North American represen-

tatives of this order. Of all the larger groups of the reptiles from the American Mesozoic, the Plesiosaurs have probably been least satisfactorily known. This is the more remarkable as the group has shown a high degree of differentiation and skeletal remains can not be considered as rarities. Thirty-four species and nineteen genera of Plesiosaurs are listed by the author. The majority of these have been known only from small portions of the skeleton and, excepting the specimens described by the author, the general osteology of no single species had been satisfactorily worked out. The full description and the excellent illustrations of *Dolichorhynchops osborni* Williston incorporated in this paper furnish for the first time the materials upon which a satisfactory comparative study of the American forms of this group can be based. Important contributions to our knowledge of the general structure of the Plesiosaurs are made by the author in his interpretation of the structure of the frontal, occipital and palatine regions. In *Dolichorhynchops*, the elements which represent what have been considered as the frontals appear to be parietals reaching forward to the premaxillaries and separating the true frontals. The supraoccipital region in this form consists of two distinct and considerably separated elements. In *Brachauchenius* the palatines and pterygoids are broadly contiguous along the median line and the openings far back between the pterygoids are thought to represent the internal nares. An important addition to the types of Plesiosaurs already known is made in the description of *Brachauchenius lucasi* Williston, based upon a large-headed, short-necked species from the Benton Cretaceous of Ottawa County, Kansas. This genus shows single-headed cervical ribs and has the peculiar characters of the palate mentioned above. The addition of this very distinct type to the numerous genera already known serves to emphasize the statement that the Plesiosaurs have shown a remarkable degree of differentiation in this country.

Professor Williston has already given us a most valuable monographic study on one of the groups of American marine reptiles, viz., the Mosasaurs, and we shall look forward with much interest to the appearance of his completed work on the order which is now engaging his attention. J. C. M.

5. *Spodumene from Pala, California.* — The beautiful amethystine spodumene from Pala, San Diego, Cal., which was described by G. F. Kunz in the September number (p. 264) and named *Kunzite* by Baskerville (see Science, Aug. 12, and this Journal, p. 335), is also the subject of a descriptive article by W. T. Schaller (Univ. California, Bull. Geol., iii, 265, Sept., 1903). The crystals are simple and show the forms in the prismatic zone, a(100), b(010), l(320), m(110), n(130), A(350). The peculiar etching figures are discussed and figured in detail and approximate symbols assigned to them. The following results are given as the average of several analyses:

SiO_2	Al_2O_3	Mn_2O_3	Li_2O	Na_2O	K_2O	Ign.
64·42	27·32	0·15	7·20	0·39	0·03	0 = 99·51

A view is given of the mine from which the mineral is obtained and it is remarked that the green variety of the species, hiddenite, is also found there.

III. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The autumn meeting of the National Academy of Sciences was held at Chicago from Nov. 17 to 29. The list of titles of papers presented will be given in the following number.

2. *American Association.*—The annual meeting of the American Association for the Advancement of Science will be held in St. Louis in Convocation Week, beginning on December 28. Most of the societies usually affiliated with the Association will hold their meetings at the same place and time, and joint sessions in many cases are promised. The success of the first Convocation held at Washington a year ago gives reason to anticipate an equally interesting occasion at St. Louis.

3. *Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures and conditions of the Institution for the year ending June 30, 1902.* Pp. lxvi, 687, with many plates. Washington, 1903.—The report of the Secretary, S. P. Langley, in the volume now issued, was noticed on p. 242 of the preceding volume. In addition to this and other administrative matters the volume contains a General Appendix (pp. 117–659) which presents the usual selection of interesting scientific memoirs relating chiefly to the year 1902.

4. *The Physico-Chemical Review.*—It is announced that an international review of the sciences of physical chemistry and the allied branches of chemistry and physics will be begun in 1904 with Dr. Max Rudolphi, of Darmstadt, as editor-in-chief, and with the cooperation of numerous scientists in Germany and abroad. It will contain abstracts of papers published elsewhere; these will be in French and English as well as German and will be prepared by the authors so far as possible. The Review will be issued twice a month, making an annual volume of about 860 pages. Specimen numbers will be sent post-free by the publishers, Gebrüder Borntraeger, Dessauer Strasse 29, Berlin SW.

Obituary.

Robert Henry Thurston, Director of Sibley College and Professor of Mechanical Engineering at Cornell University, died in Ithaca on October 25th, his sixty-fourth birthday.

Professor Henry Carrington Bolton, the well known chemist and author, died in Washington on November 19 at the age of sixty years.

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